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# INDEX TO VOLUME XLIV.



CURRENT TOPICS:

Mr. R. A. S. Redmayne, C.B., H.M. Chief Inspector of Mines, has recently been prominently before the public eye in connection with the reports he has presented on the subject of colliery accidents. Born at Gateshead on July 22nd, 1865, he was educated at Durham College of Science, gaining his first practical experience as mining apprentice at the Hetton Collieries Co., Durham, in which company he afterwards became under-manager. Having gained further mining experience in South Africa, he became manager to the Seaton Delaval Collieries in Northumberland, and later Consulting Mining Engineer and Professor of Mining in the University of Birmingham, and a director of large colliery and iron smelting undertakings in North Staffordshire. He relinquished these posts early in 1908 to take up the newly created position of Chief Inspector of Mines at the Home Office. He has sat on numerous Commissions and Committees and has written several volumes on mining, and has been a frequent contributor to scientific and industrial journals. He is an M.Sc. of the University of Birmingham, a member of the Institute of Mining Engineers, a member of the Council of the Institute of Mining and Metallurgy, as well as a member of the Institution of Civil Engineers and a Fellow of the Geological Society. He has travelled largely in most of the mining districts of America, South Africa and the Continent of Europe.

*Photo by* ] [ *Elliott & Fry.*

R. A. S. REDMAYNE, M.Sc., M.Inst.C.E., M.I.M.E., F.G.S.

See reverse side.

# CASSIER'S MAGAZINE

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## SOME NOTES ON DIFFERENTIAL GEARS FOR VARIOUS TYPES OF MOTOR VEHICLES

By William Fletcher

THE object of this article is to illustrate and describe various types of differential gears and locking arrangements that have largely been used in practice, for steam tractors, traction engines, steam wagons, and for petrol vans. Some of the early forms of differential gears are included, and more of the very latest types are illustrated. The compensating gear is a very important factor in all self-propelling machines; and as a detail of the transmission it has a most useful purpose to fulfil. No road engine of any type can be satisfactory if it is not fitted with a well constructed and efficient differential gear, while the locking arrangement of the tractor and other quick running vehicles, is of the most vital importance.

In a paper entitled, "Steam on Common Roads," read by Mr. John McLaren, before the "Inst. of Civil Engineers," in November, 1870, it was said:—"The compensating gear was first employed in White's dynamometer, and published in his "Century of Inventions," in 1832.

It was first used for steam vehicles by Mr. R. Roberts, the celebrated Manchester engineer and tool maker, in 1834. Fig. 1 shows his arrangement of the compensating gear. Upon examining the illustration it will be seen that so long as the driving wheels continue to run in a straight line, the tubes do not revolve upon the axle, but revolve with it, and carry round the wheels as if they were fixed to the axle; but when any deviation from the straight line takes place, the bevel wheels, while advancing with the axle, revolve upon the axle, in contrary directions, so that the advance of the outer driving wheel exceeds that of the inner wheel by as much as the length of the outer curve exceeds that of the inner curve, and thus skidding is prevented by this arrangement. Previous to the employment of the differential gear on wheel carriages, claw clutches, friction bands, ratchet wheels, and other complicated arrangements were used for obtaining the full power of both the driving wheels, and at the same time allowing the motor to turn the sharpest corner easily or clumsily, as the case might be. In nearly every case one wheel was liberated, and only one used for driving.

Before proceeding to deal with the compensating gear, it may be of

interest to mention some of the numerous methods for allowing carriages to turn corners without skidding. A number of early road vehicles were made, having two quite separate engines mounted on the boiler, and so arranged that one motor could be run at a slower rate than the other for turning sharp curves, the transmission on each side was quite distinct. In other cases the driving wheels were not keyed direct to the axle, but bosses of the driving wheels were provided with ratchet discs, and spring pawls, like in Fig. 2.

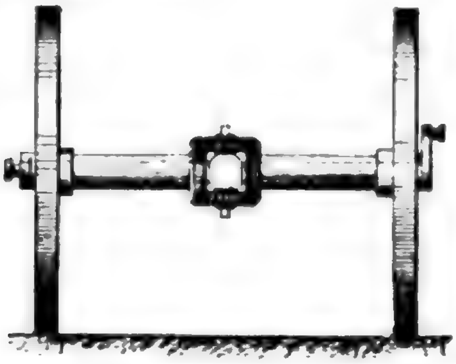


FIG. 1.—DIFFERENTIAL GEAR. BY RD. ROBERTS.

The ratchet wheel was keyed to the axle, and it drove the wheel by means of the spring pawl; this device allowed the outer wheel to run faster than the inner one when the carriage described a curve, and still be ready to receive the impulse of the motor as soon as the vehicle returned to a straight course. When it was necessary to back the car, the ratchet had to be locked. In many cases two driving pins were used, one

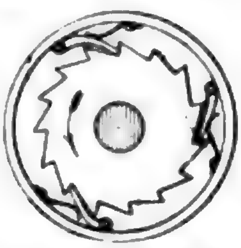


FIG. 2.—RATCHET ARRANGEMENT.

of which had to be drawn by a man in attendance when the engine was about to round a curve, this system was used for many years in all types of self-propelling engines, and on old engines it is not quite extinct to-day. Another plan largely used was the friction strap and drum. A strap pulley was keyed to the axle outside the driving wheel on one side. One spoke of the wheel was made much stronger than the rest. A lug was forged on this wide spoke, the ends of the strap brake were attached to this by a strong bolt and a spring. When the bolt was tightened the pulley strap and the driving wheel all revolved together, and were locked; both the driving wheels acted as positive drivers. When the brake strap was released, the driving wheel could slip and run faster or slower, as was needed to turn corners. On some engines, geared on both sides, a clutch on the countershaft could be thrown out of gear by the driver on the footplate, and one wheel thus thrown out of action. In the cases of the two driving pins, and the friction clutch, it was necessary for a man to be on the road to actuate the needed change. There were other methods of allowing the engine to turn which need not be described.

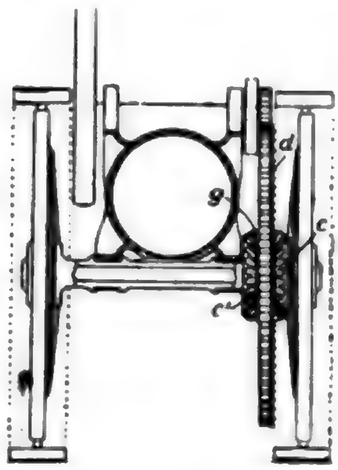



FIG. 3.—MESSRS. FOWLER AND BURTON'S PLAN.

Messrs. Fowler and Burton patented in June, 1857, a small road engine as shown in cross section, Fig. 3. The driving wheels are mounted on a tubular main axle, on which the compensating gear is arranged as shown, so that each driving wheel can rotate independently of the other. The adjacent ends of the two parts of the axle are fitted with bevel wheels, C and $C^1$, which gear with planetary bevel wheels g, carried by the spur wheel d, driven by a pinion on the crankshaft. One of the driving wheels can thus rotate faster than the other when the vehicle is being turned. This is a very early and simple arrangement of differential gear. Messrs. Aveling and Porter fitted

a simple form of compensating gear to a combined traction engine and crane, which appeared at the Leicester Royal Show, 1868; this small vehicle was chain driven. In 1876 Messrs. Chas. Burrell and Sons patented the combined compensating gear, and winding drum something like Fig. 4. This arrangement was adopted by several

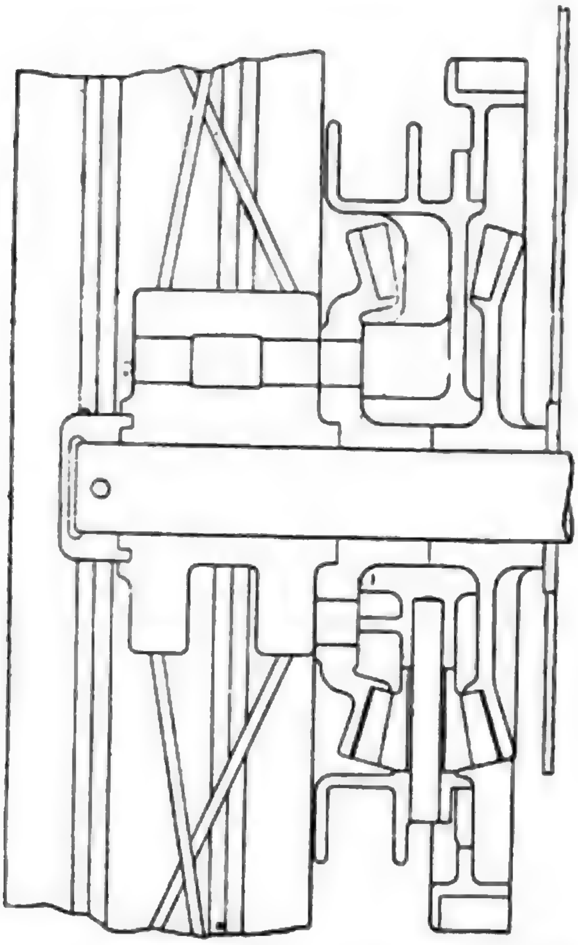


FIG. 4.—COMPENSATING GEAR AND WINDING DRUM BY MESSRS. C. BURRELL AND SONS.

makers under Royalty. The bevel wheel nearest to the horn plate is keyed to the axle, the other bevel wheel rides on the axle, and is not bolted to the nave of the driving wheel. A sliding pin connects the outer bevel wheel to the nave for driving; the compensating gear then being in action. When the pin is thrust through the bevel wheel, and forced further into the compensating plate the gear is locked. As will be seen the compensating plate rides on the bosses of the two bevel wheels; a much better plan than to allow the plate to revolve on the smaller diameter of the axle. One advantage of this arrangement of gearing is the fact that the axle remains stationary when the drum is being used, the pinions revolve on their studs and cause the loose bevel wheel to revolve on the axle. The spur ring is strongly bolted to the compensating gear plate; if the drum is of steel, like the gearing they will be rivetted together. Fig. 5 illustrates another plan of compensating gear, in which the brake drum is formed in the same casting as the plate. In this instance the gear is shown locked; the gear is so arranged that the centre of the main pinion is quite central with the bevel wheel joint of the bosses, that is, a vertical line would pass through the centre of the compensating gear, and through the centre of the face of the spur pinion. A gear planned thus works sweetly, and there is no side thrust tending to force the bevel wheels out of mesh, this is a point that is often disregarded. Fig. 6 shows a small differential gear for a 5 ton four shaft tractor, with the locking pin clear of the wheel boss, and the boss for same is formed in the bevel wheel shroud. A table is given below of the dimensions of a 4 ton, and 5 ton tractor set of gearing :—

| | 4-ton Tractor. | 5-ton Tractor. |
|---|---|---|
| Pitch of bevel gearing .. | 2[illegible] ins. | 2[illegible] ins. |
| Diameter of bevel wheels .. | 16[illegible] ins. | 20 ins. |
| Width on face .. .. .. | 2[illegible] ins. | 3 ins. |
| Diameter of bevel pinion .. | 5[illegible] ins. | 6[illegible] ins. |
| Width on face of pinion .. | 2[illegible] ins. | 3 ins. |
| Diameter of pinion studs .. | 1[illegible] ins. | 1[illegible] ins. |
| Number of pinions .. .. | 3 | 2 |
| Number of cogs in bevel wheels .. .. .. | 24 | 25 |
| Number of cogs in bevel pinions .. .. .. | 8 | 8 |

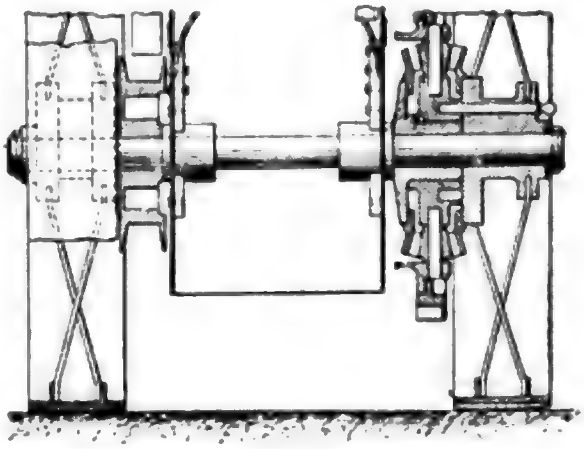


FIG. 5.—COMPENSATING GEAR AND BRAKE DRUM, BY MESSRS. AVELING AND PORTER.

In Fig. 6, it will be seen that the outer bevel wheels are cast with a shroud, or flange at the large end of the teeth. This makes the machining more difficult, but adds to the strength of the cogs and the disc. Though the inside bevel wheel is not flanged, the teeth of the outer one are flanged for a definite purpose, as already pointed out. Moreover it may be noted that the bevel wheel nearest the horn plate is keyed to the axle, for driving the left hand road wheel: the outer bevel wheel is bolted to the nave of the right hand driving wheel as shown. Fig. 7 represents a combined slip winding drum and compensating gear, as are mostly used in the tractors running under the L.G. Board regulations. A word or two of description only is needed; a projecting hoop or pulley is cast with the compensating plate, the slip drum is mounted on this hoop, and runs freely on it; the drum is kept in place sideways by a ring bolted on the outer edge. The slip drum carries a spring driving pin, which when held up allows the drum to run freely for paying out the wire rope: when the pin is released the spring causes it to fall into a hole provided for it, the drum and the compensating gear casting are then locked together, for winding in the rope.

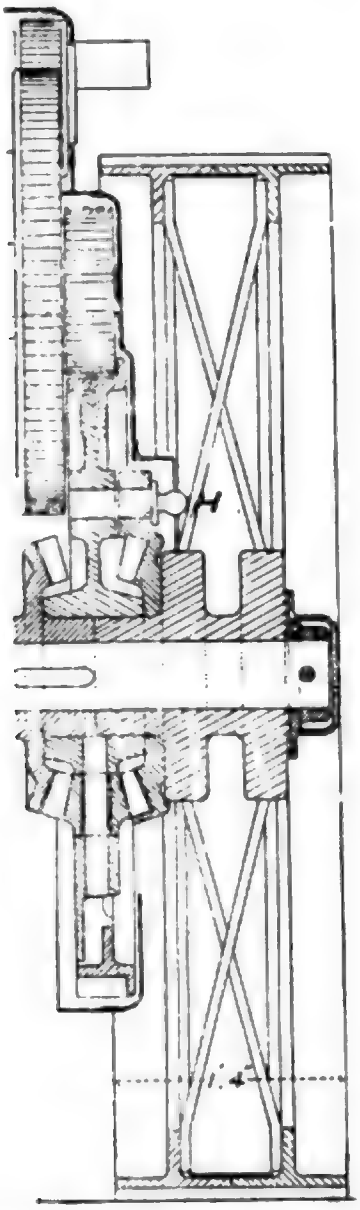



FIG. 6—DIFFERENTIAL GEAR AND LOCKING PIN.

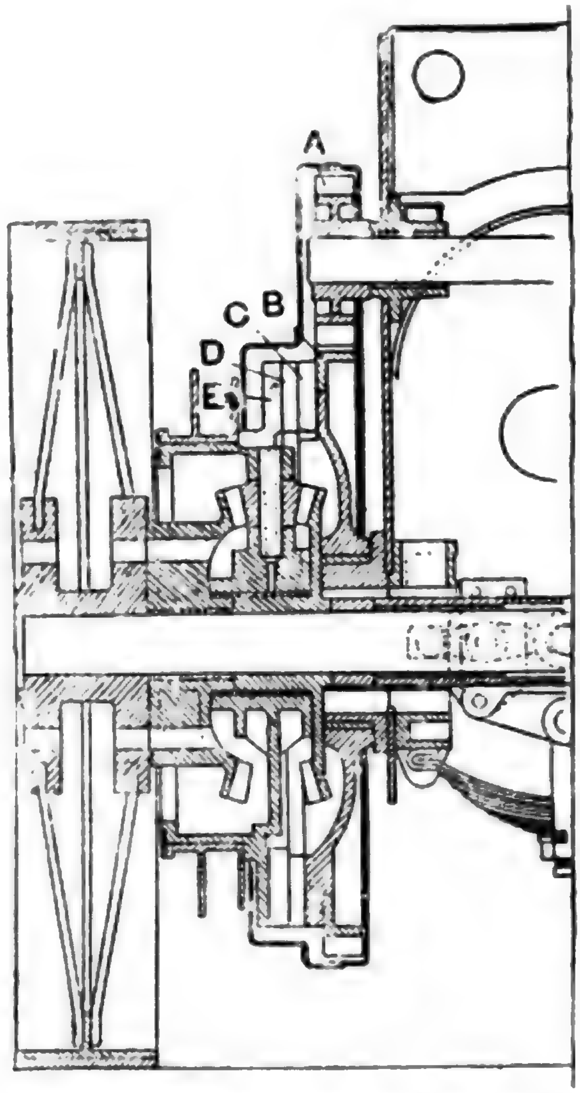



FIG. 7.—DIFFERENTIAL GEAR AND SLIP DRUM.

Fig. 8 represents a portion of the main axle, and the right hand side wheel of the "Sentinel" steam wagon as made by Messrs. Alley and MacLellan The axle (like vehicles of this type) is

in one piece. The left hand side bevel wheel of the compensating gear is keyed to the axle, the left hand road wheel is also keyed to it. The right hand side bevel wheel of the compensating gear is bolted to a flange forged on the sleeve which rotates on the axle, a similar flange on the sleeve drives the road wheel which is bolted to it, as shown. A chain from the engine drives the central plate of the compensating gear; it is lined with gun metal, and mounted on the axle. This carries the bevel pinions in the usual manner. At the right hand end of the axle a disc is keyed on, by inserting the pin through the disc into a hole in the boss of the driving wheel as shown, the compensating gear is locked and both the driving wheels are in effect keyed to the axle, and are positive drivers. When the pin is withdrawn, the driving wheels are actuated through the compensating gear in the usual manner for regular driving.

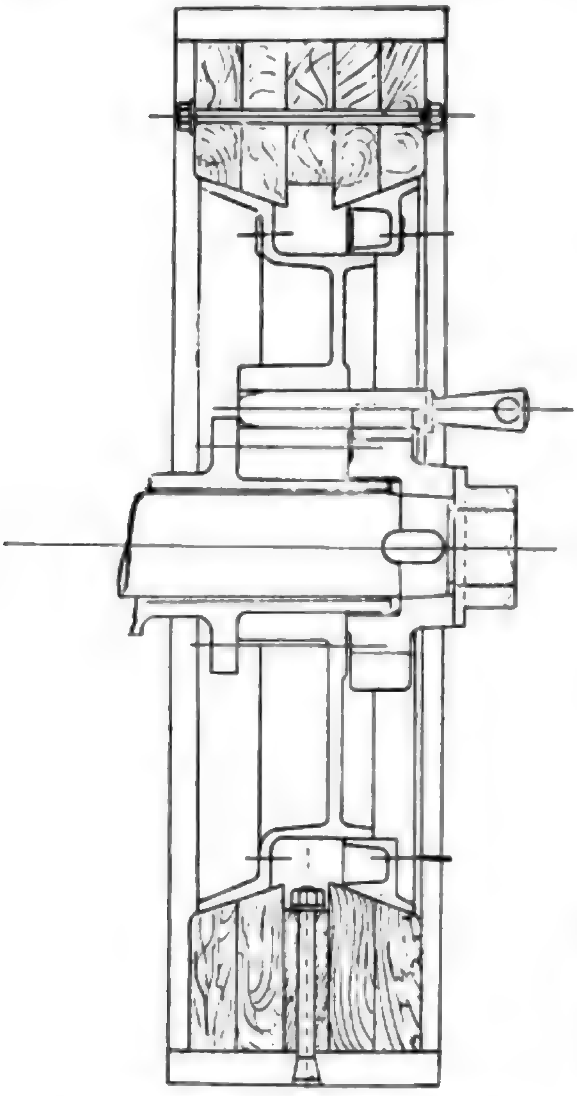


FIG. 8.—ROAD WHEEL AND LOCKING PIN. BY MESSRS. ALLEY AND MACLELLAN.

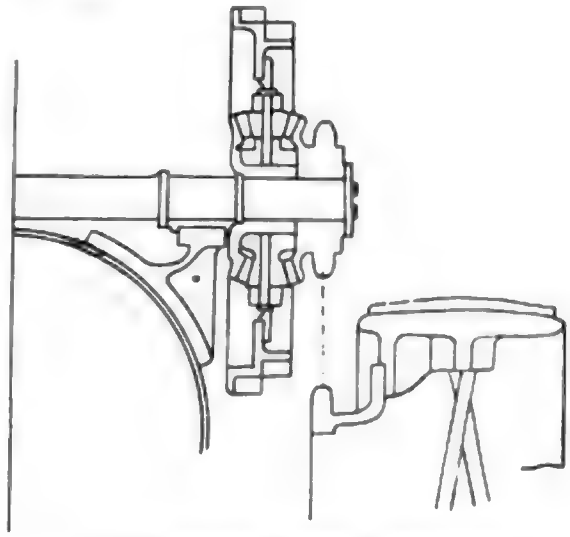


FIG. 9.—DOUBLE DRIVING ARRANGEMENT BY MESSRS. C. BURRELL AND SONS, THETFORD.

Fig. 9 shows a double driving arrangement on a chain driven road engine made by Messrs. Chas. Burrell and Sons in 1876 or 1877. The compensating gear is mounted on a countershaft, the right hand bevel and the chain pinion are cast together, and revolve on the shaft, the left hand bevel wheel is keyed to the counter-

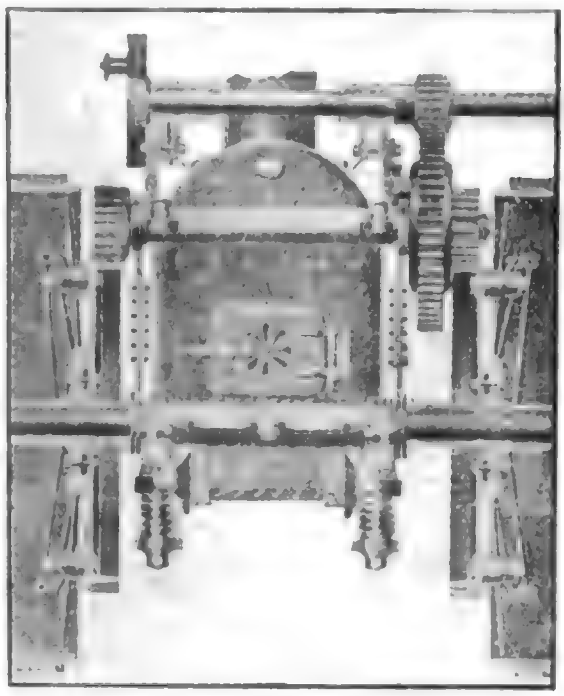
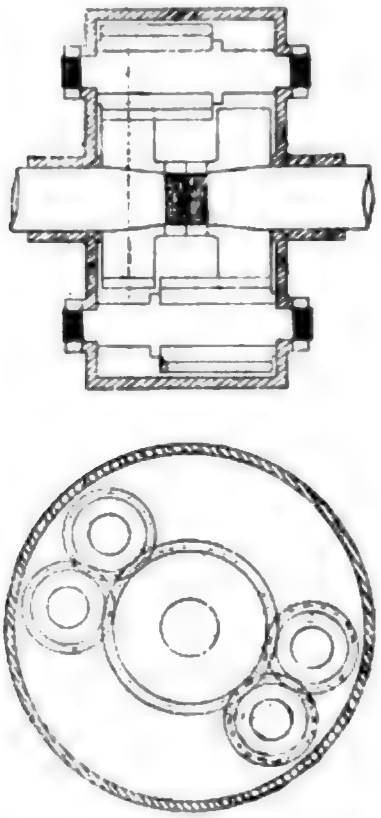


FIG. 10.—DOUBLE DRIVING ARRANGEMENT. BY AMERICAN MAKER.

shaft. A double speed spur ring is bolted to the compensating plate, which is mounted on the boss of the left hand bevel wheel. The chain pinion drives the right hand wheel, another pinion, is keyed to the counter-shaft, for driving the left hand road wheel.



FIGS. 11 AND 12.—SPUR COMPENSATING GEAR.

Another double driving arrangement is illustrated by Fig. 10. A spur pinion communicates motion to the compensating gear plate, the bevel pinions are arranged in the plate in the usual manner. One bevel wheel and the main spur pinion are cast together for driving the right hand road wheel, the outside bevel wheel is keyed to the countershaft, and so is the main pinion for driving the left hand road wheel. The countershaft is supported in a sleeve or cannon as shown, the spur rings communicate motion to the periphery of the driving wheels.

In one American example a diagonal shaft is employed for communicating the motion from the crank shaft to the axle. At the axle end of the diagonal shaft, a small bevel pinion meshes into a large bevel wheel on the axle, this bevel wheel is the compensating plate and carries two bevel pinions, one bevel wheel is keyed to the axle for driving the left hand wheel, the right hand bevel wheel is connected to the right hand road wheel boss. This forms a very snug arrangement of compensating gear.

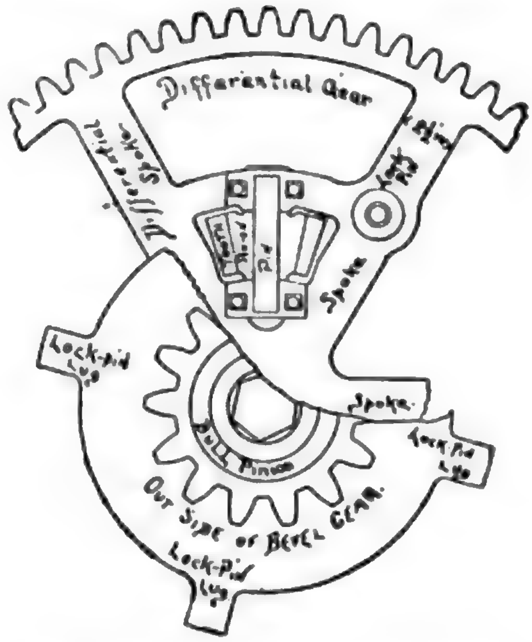



FIG. 13.—PORTION OF DIFFERENTIAL GEAR.

Figs. 11 and 12 show views of a spur gear differential arrangement which is occasionally used on motor cars, and never used on tractors or steam wagons. M. Serpollet in his steam cars used this form of differential gear. It was considered a cheaper type to make, but the spur wheel gear requires a very much larger casing, and is considerably heavier than the bevel

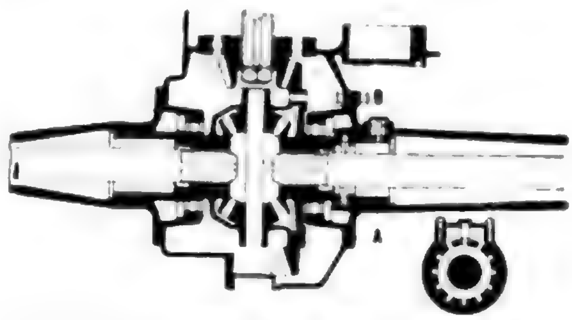


FIG. 14.—COMPENSATING GEAR. BY MESSRS. JOHN I. THORNEYCROFT, LTD.

form. From Fig. 11, it will be seen the studs are three times the width of the pinions, and are very likely to spring unless they are made of great strength. Taking it all round the bevel gear is the better system to adopt.

Fig. 13 illustrates a portion of differential gear cut away to show the bevel pinion arranged in the intermediate spur wheel. The outside of the bevel wheel, and the bull or main pinion are also seen ; the hole for the lock pin is formed in one of the spokes of the wheel, while lock pin lugs are cast on the outside of the bevel gear wheel.

An interesting arrangement of compensating gear is illustrated by Fig. 14, it is the countershaft gearing of Messrs. Thorneycroft's 16 h.p. van. A bevel pinion on the cardan shaft transmits motion to the bevel wheel, this carries with it the compensating box, with the bevel pinions and the stud on which the pinions rotate. The compensating gear box rides on the bosses of the two bevel wheels, long bosses are provided on the two wheels for being keyed to the ends of the counter-shaft. Ball bearings are provided for the cardan shaft, the compensating gear box, and the outer ends of the divided counter-shaft near the chain pinions ; the final transmission is by side chains. The lubrication of the whole of the gearing is well carried out.

By the courtesy of Messrs. John I. Thorneycroft and Co., Ltd., we are enabled to illustrate the worm driven compensating gear and details for the rear axle of one of their noted cars. Fig. 15 shows a longitudinal section of the axle, the compensating gear, and the casing. The motion to the worm shaft is transmitted through a universal joint. As will be seen ball bearings and thrust bearings are provided for the worm shaft, and they being at the bottom, run in an oil-bath. The compensating gear is placed in the centre of the axle, the worm wheel is bolted to the compensating box, which encloses the bevel wheels for the axle ends, and those on the massive stud, but the box only communicates motion to the pinions on the stud, and when not revolving on the stud, act as drivers to the bevel wheels on the axle. Heavy bushes are provided for the planetary wheels on the stud, and they are washered up to keep them in place. The two bevel wheels on the axle are firmly keyed to the ends, and they revolve with the axle in bearings provided for them. Ball bearings and ball thrust bearings are provided for the box itself, it having a long neck on each side, the ball bearings and thrust rings are washered firmly together on the necks. All this is most neatly constructed. The axle on each side extends to the hub of the road wheels,

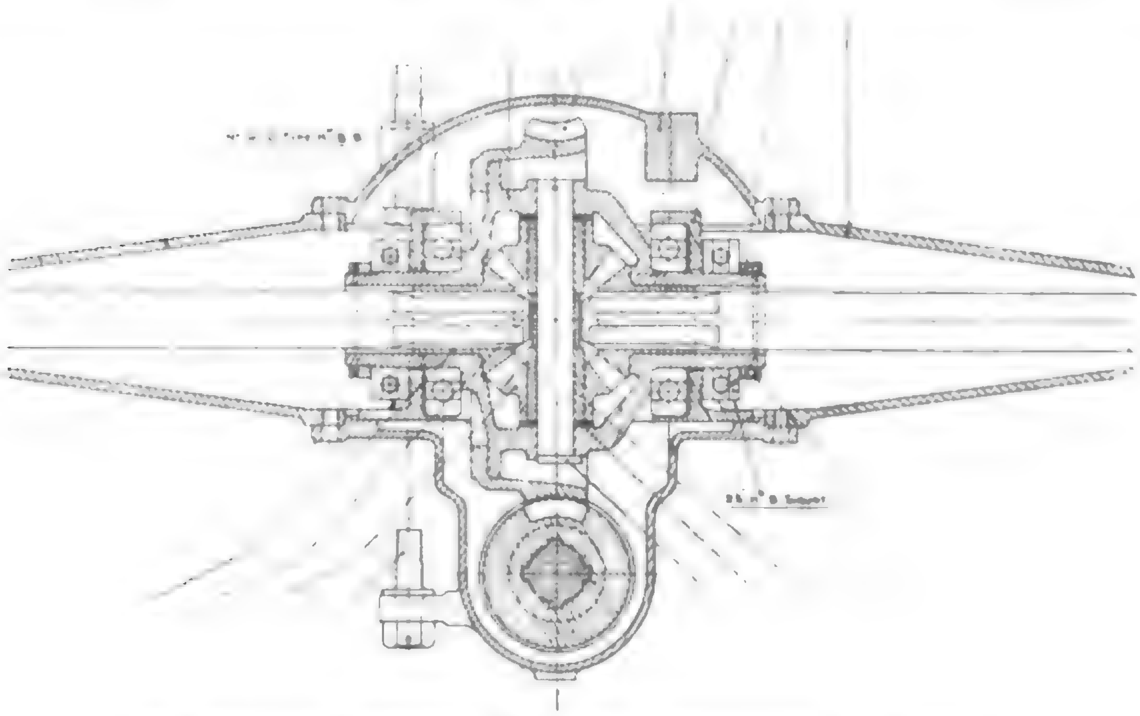


FIG. 15.—GENERAL ARRANGEMENT OF MESSRS. THORNEYCROFT'S WORM DRIVE.

the wheels are driven, each from one of the differential bevel wheels; the axle casing carries the hub of the wheels; and the brakes contained in the hub on each side. On the axle casing seats are also provided for the plate springs. Over the compensating gear suitable lids are provided for gaining access to the whole of the central gearing contained in the box. The trough containing the worm and shaft can be readily disconnected, and allowed to drop when necessary. A direct worm drive of this type is a far simpler arrangement than the double chain drive from the counter-shaft to the axle, the number of wearing parts is much reduced also.

Fig. 16 represents a sectional view of a differential gear arrangement constructed by Messrs. E. G. Wrigley & Co. for a 15 to 18 H.P. pleasure car rear axle or a two to three ton van counter-shaft. The cardan shaft drives the bevel wheel and the compensating gear box by means of a pinion as shown. This box revolves on the bosses of the bevel wheels on the ends of the countershaft, and carries with it the studs and pinions securely fixed in their place. Ball thrust rings are provided for the box behind the bevel wheels and fitting up to the casing. The countershaft ends are turned and keyed to the bevel wheels, one wheel for each part of the counter-

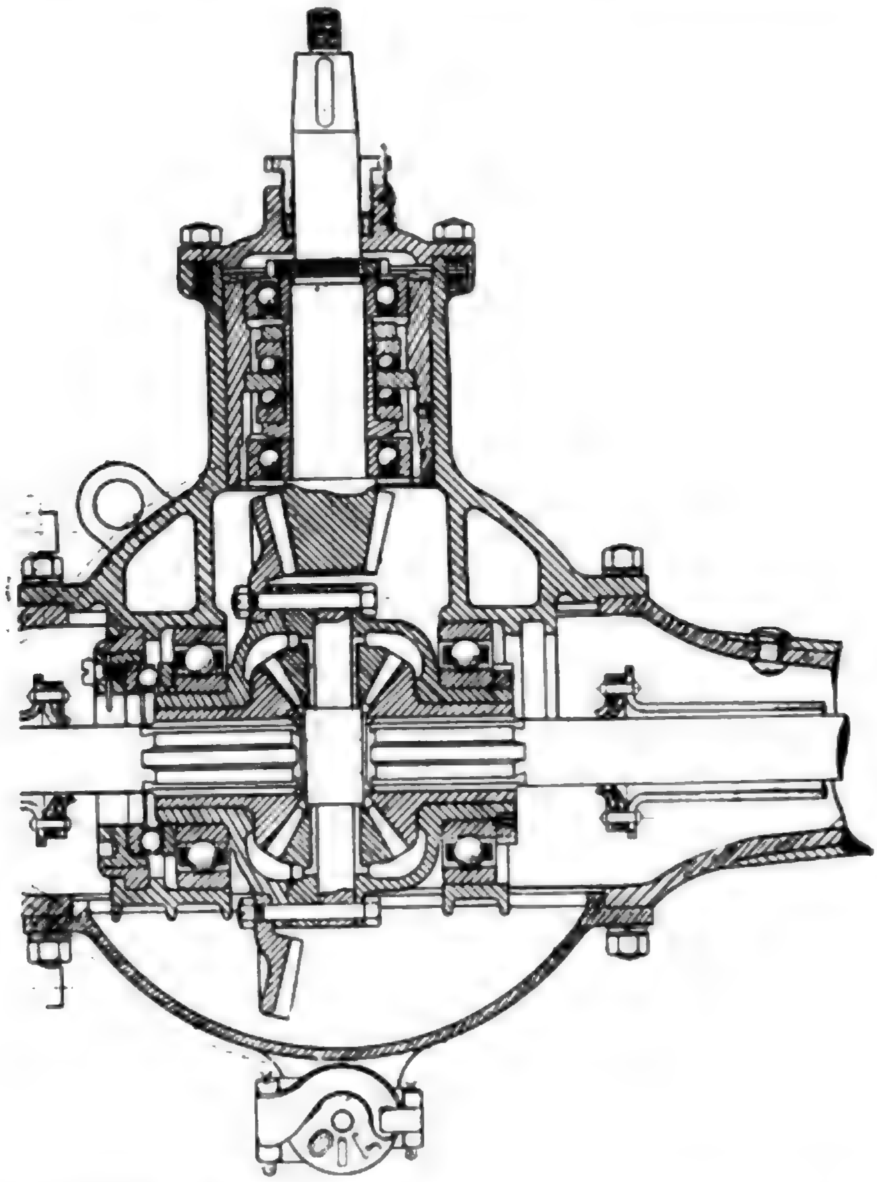


FIG. 16.—DIFFERENTIAL GEAR ARRANGEMENT. BY MESSRS. E. G. WRIGLEY AND CO., LTD. OF BIRMINGHAM.

shaft divided in the centre. In the sleeve on each side of the casing two ball bearings support the countershaft. The casing is divided in the centre, as shown, and fastened together by bolts. All the parts are neatly held in the places; the bushes and the bearings of the bevel wheels are soundly carried out, so as to hold the bevel wheels and pinions in perfect mesh. The pinions on the stout studs are cottered up to keep them centrally to their work. Any of the parts can be opened up for inspection when required. This compensating gear is of the most recent design and its construction leaves nothing to be desired.

A fine example of compensating gear is shown in section by Fig. 17, this is intended for the rear axle of a 20 to 30 H.P. car or light van to carry about two tons. This gear is also made by Messrs. E. G. Wrigley & Co. It is a worm driven type, the worm in this instance being placed at the top. As in some previous types, the gear box

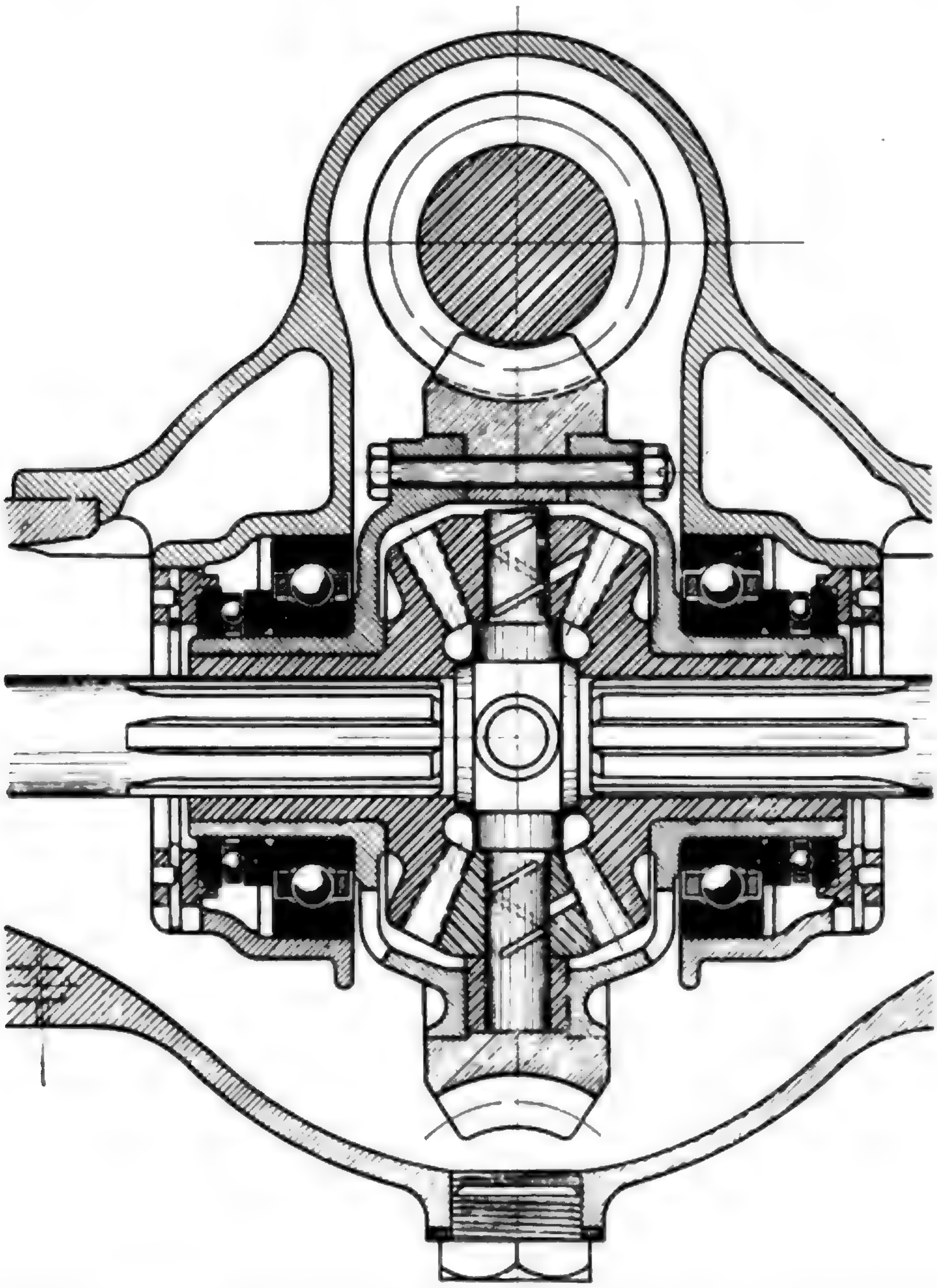
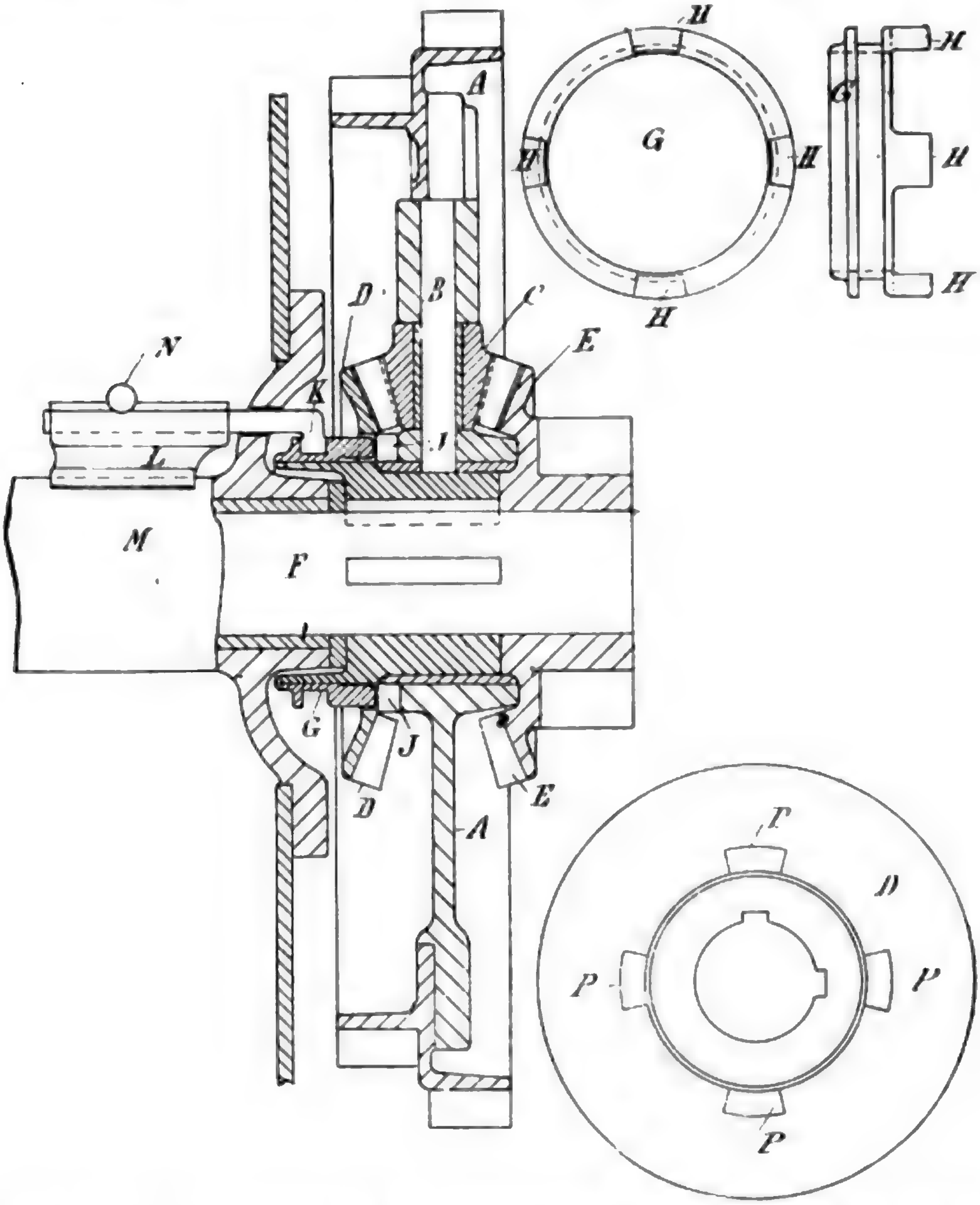


FIG. 17.—DIFFERENTIAL WORM DRIVE. BY MESSRS. E. G. WRIGLEY AND CO., LTD., BIRMINGHAM.

is free to revolve on the bosses of the bevel wheels, and carries with it the studs and planetary pinions. The ball bearings are close up to the backs of the bevel wheels, as shown. The $2\frac{3}{4}$ in. Hoffman's thrust collars are clearly shown; the top of the gear box can be readily removed for the inspection of the working parts, by simply slacking the fly nuts. As in the previous illustration, the gear box casing is made in halves, and well bolted together. An adjustable strut bar is fitted to the under side of the box to stiffen the rear axle casing. The box is filled with grease when assembled.

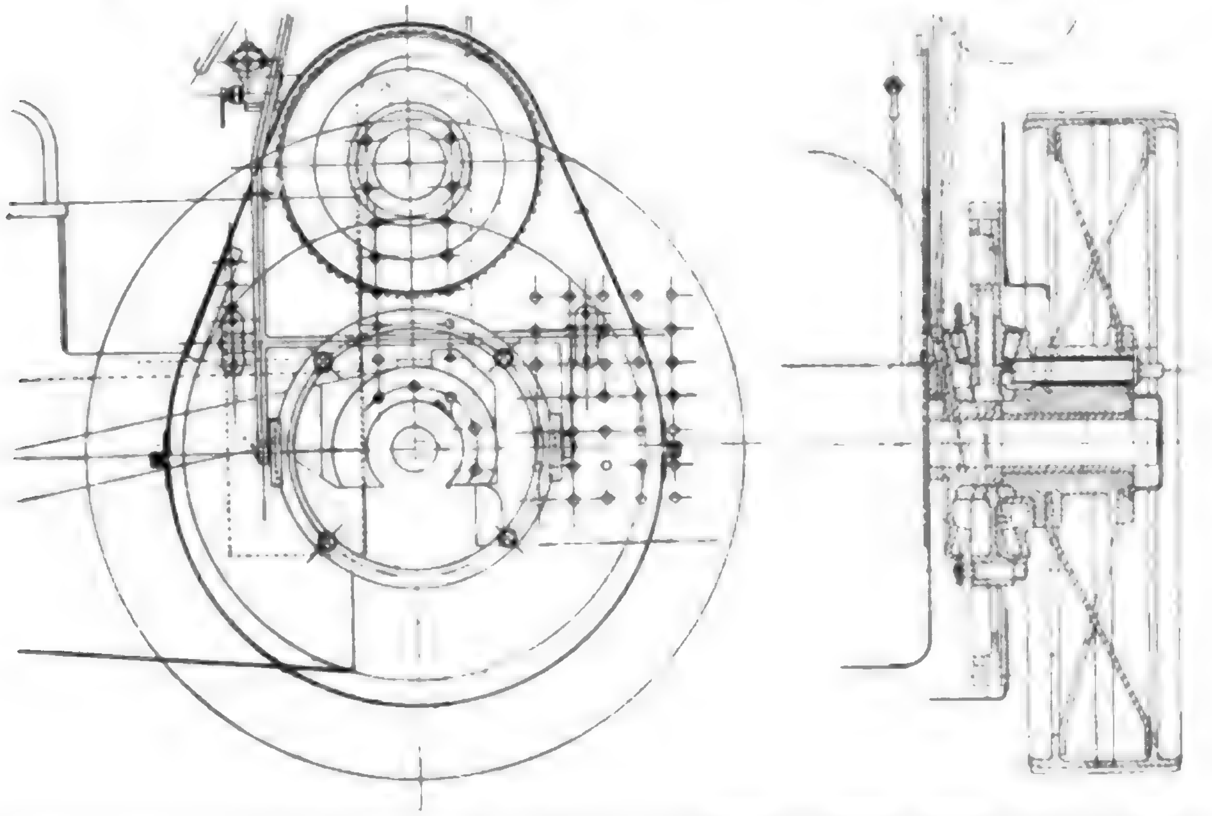
From a lengthy experience we prefer three compensating pinions instead of two, four, or six. Three pinions form a perfect balance, and work well in practice. The pinions are often made in wrought iron, cut out of the solid material, carefully machined, and case hardened; and they should be bushed with gun-metal, or phosphor bronze. If the bevel wheels are not machined,



FIGS. 18, 19 AND 20.—COMPENSATING GEAR LOCKING PLAN. BY MESSRS. C. BURRELL AND SONS, LTD. OF THETFORD.

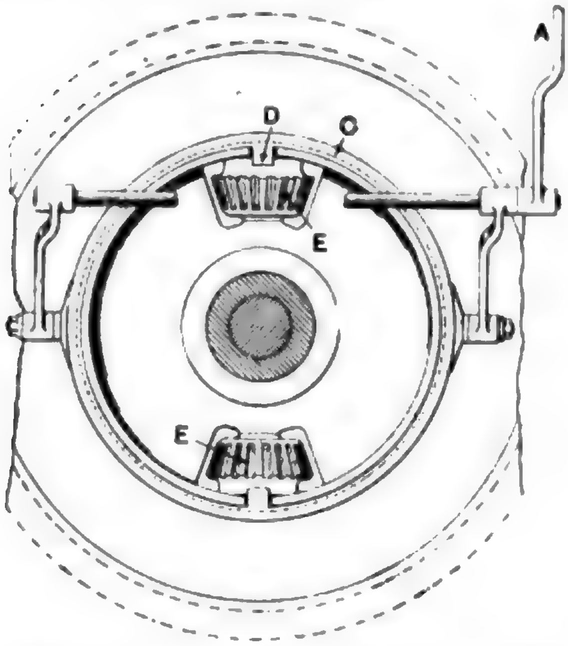
they should be cast from machine-cut iron patterns; and the compensating gear carefully constructed so that no chipping of the cogs is required. The studs or mandrils for the pinions should be made of the best hardened steel. On a previous page a table of compensating gear dimensions was given for two sized tractors, these have been hard worked for years and have given perfect satisfaction, while no breakages have occurred under fair working conditions. The very best cast steel is used for all the gearing, and for the compensating plate also. A most important matter is the perfect system of lubrication to be adopted; on motor cars and steam wagons the differential gear can be run in an oil bath, but in tractors and traction engines this is not easily accomplished.

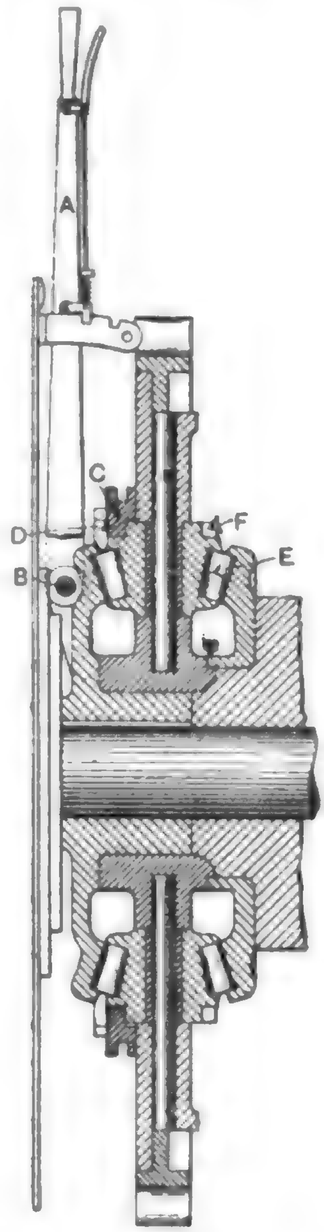
Messrs. Chas. Burrell & Sons patented a simple plan for locking the compensating gear on the countershaft of their double geared engines, which has acted perfectly in practice. The following is a brief description of the same. Fig. 18 is a longitudinal section of the differential gear. Fig. 19 are side and end elevations of the clutch ring. Fig. 20 is an end view of the toothed wheel D. The gear itself is formed of a central driving wheel A, carrying three radial pins B, on which are mounted toothed pinions C, which gear into two toothed wheels, D and E. One of these wheels D, is fast with a central shaft F, by which the wheels D and E are carried, the latter being loose upon it. Motion is transmitted to one road wheel from the shaft F, and to the other driving wheel from the loose wheel E. A prolongation of the outer end of the boss of the bevel wheel D, which is fast with the shaft F, is surrounded by a loose clutch ring G, on which are projections H, which enter recesses P, formed through the wheel D, so that the clutch ring always revolves with the wheel. The projections are made of such a length that if the ring be slidden towards the wheel, the ends of the projections may be made to pass also into recesses I formed in the boss of the central driving wheel A, and thereby cause this wheel to be locked to the bevel wheel D, and so put the gear out of action. To be able to move the clutch ring G to and fro



FIGS. 21 AND 22.—COMPENSATING GEAR LOCKING PLAN. BY MESSRS. J. FOWLER AND CO., LTD., OF LEEDS.

towards or away from the wheels, the ring is formed with a groove around it, and a tongue U projecting from a slide which is parallel with the shaft is made to enter this groove. Thus the gear can be either locked or set free to come into action whenever desired, without its being necessary to stop the engine to allow of the locking or unlocking of the gear being effected. From Fig. 18 it will be seen the double speed spur ring is bolted to the central plate A. The first claim of the patent is :—In differential gear in which a central driving wheel turning loosely around the axle of a pair of road wheels carries pinions gearing with two toothed wheels on opposite sides of it, one toothed wheel driving one road wheel, and the other toothed wheel driving the other road wheel, the




FIGS. 23 AND 24.—COMPENSATING GEAR LOCKING ARRANGEMENT. BY MESSRS. GARRETT AND SCHMACH.

employment of a clutch ring G surrounding the boss of one of the two toothed wheels and revolving with it and which, by being moved endwise on the boss is made to lock this toothed wheel to the central driving wheel.

### Compensating Gear Locking Arrangement.

Messrs. John Fowler & Co., Leeds, have recently introduced a simple locking gear for their traction engines, which can be operated from the foot plate. Figs. 21 and 22 show the arrangement clearly. The driving wheel by means of a strong pin passing through the nave of the driving wheel into a boss cast on the bevel wheel. These two wheels are not keyed on the axle, the main wheel is suitably bushed to allow for this arrangement. A ring carrying four locking pins revolves with the central plate, around the inside bevel wheel which is keyed to the axle in the usual manner. The four pins are provided with bosses in the central plate as shown. By a slight movement of the actuating lever, the ring and pins are forced outward, the pins entering lugs on the outside bevel wheel, thus locking the

compensating gear; that is, the compensating plate, the outside bevel wheel, and the main driving wheel are fastened to each other, so must all revolve together. To release them and cause the compensating gear to act, the locking pins must be drawn into the bosses of the plate, clear of outside

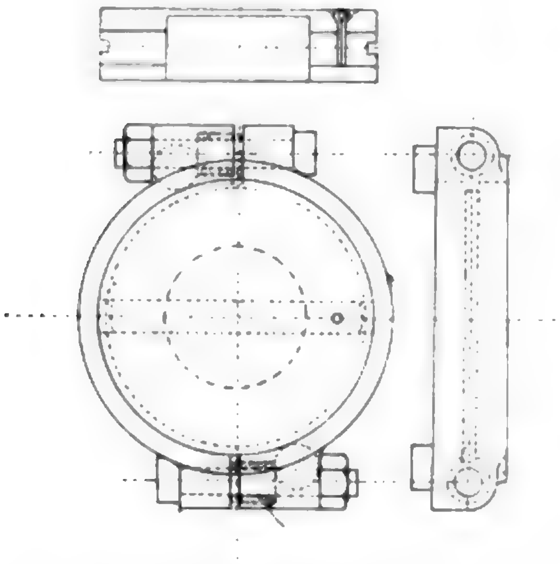


FIG. 25.—COMPENSATING GEAR LOCKING PLAN. BY MESSRS. FOSTER AND CO., LINCOLN.

bevel wheel. The side elevation shows the levers for moving the ring and the locking pins. The differential locking device patented by Messrs. Garrett and E. Schmach is illustrated by Figs. 23 and 24. According to this invention the compensating gear is locked by operating the lever A, which works in conjunction with a notched quadrant, being held positively in either position. This lever turns about its pivot B, and moves laterally a clutch ring C, which is formed with projections D. The differential pinions E are formed with a number of recesses F adapted to be engaged by the projections D on the clutch ring C. Thus when the lever A is operated, the differential pinions are prevented from rotating on their spindles, consequently the differential gear is rendered inoperative, and both road wheels rotate together. "This gear can be used on slippery ground, or wherever there is any tendency for the driving wheels to slip round, as when mounting a hill with a load behind." An efficient locking gear is more necessary when a load is being taken down a hill, for unless locked the wagons have a tendency to slew the motor out of its course. Fig. 25 represents views of the locking gear made by Messrs. W. Foster & Co. It is of the friction strap arrangement. A collar is pinned to the end of the axle, having a $\frac{3}{8}$ in. groove turned in the centre of it on the outside. The strap revolving on the collar is seen. A $\frac{7}{8}$ in. cast steel pin connects the collar with the axle. When the strap runs loosely on the collar the compensating gear is in action, by tightening up the strap the nave and the axle are locked. In addition to the three firms mentioned whose compensating gear can be locked from the foot plate, may be mentioned Messrs. Mann's Patent Cart and Wagon Co. and Messrs. Clayton and Shuttleworth. For the quick running tractors and motor wagons, this easy and rapid locking gear actuated from the foot plate is of the utmost importance, if accidents are to be prevented. There are other locking arrangements in use which are not included owing to want of space, but these given are worthy of careful study.

# TESTS OF HIGH POWER BOILERS

By F. Revord

IT is proposed, in this article, to deal with the practical tests applied to high pressure steam generators, particularly with regard to the method of procedure when testing such boilers for wear and waste, and the importance of the data obtained from such tests.

The water pressure test is intended primarily as a test of the structure of the boiler, as it does not always follow that a boiler which withstands the hydraulic test will equally well stand a steam test, and practically all modern boilers are subjected to a steam test, following the hydraulic test, before leaving the manufacturers. In a water tank boiler one may reasonably assume that, should the hydraulic test be satisfactory the steam test will also be satisfactory, but this by no means applies to high pressure water tube boilers. The reason for this is at once apparent when the difference in the nature of the various parts of the structure is considered, and also when one considers the greater number of connections, joints, etc., in this type. From the nature of their construction in many cases, the various parts, such as tubes, headers, sediment chambers, drums, etc., cannot be manufactured from the same grade material, and the differences set up in these parts at high temperatures might probably cause a steam leak. In water tube boilers the hand hole door joints, although quite tight under hydraulic pressure, frequently exhibit signs of leakage when steam is raised, so that the importance of the steam test is still further demonstrated. As regards regulation of the steam pressure, the best modern practice is to adopt the Admiralty rules, which are as follows:—When the safety valves are loaded to 90 lb. per square inch the hydraulic pressure should be double the load; when the load is between 90 and 180 lb. the pressure should be 90 lb. per square inch greater than the load; when the load is 180 lb. and above, the test pressure should be 50 per cent. above that load. When steam testing the working steam pressure is generally taken. In all hydraulic tests the safety valves require to be gagged, that is, so secured that they cannot possibly lift as the pressure rises, and it is usual to double shut off all water gauge mountings to avoid fracture of the gauge glasses at such high pressures. At this juncture it is as well to note that should a steam pump be used for the water pressure test, all connections between the boiler under test and any pipe or pipes containing steam should be blank flanged off. New boilers after being tested by the manufacturers are usually steamed for a definite period before subsequent tests are applied. It is the usual practice to apply a hydraulic test after a boiler has been in use for a period of from 18 months to 2 years, and subsequently at half-yearly intervals.

The test for wear and waste is the most important that a boiler is subjected to, and it is the only definite method whereby a correct estimate can be obtained as to the durability of the component parts. From this test the

life of the various parts are calculated, and the value of the boiler as a steam generator at the time of the test determined. The test for wear and waste is carried out after the boiler has been in use for a period not exceeding two years, after which it is usual to test at periods of from 18 months to two years. Should a group of boilers of the same age, and which have approximately done the same amount of work, require drill testing, it is usual to select a percentage of the total number, and the result should give a good general idea as to the condition of the remainder. In a battleship, for instance, in which there are three stokeholds, each being a separate watertight compartment, it is usual to test one boiler in each group, this method enabling the officer in charge to estimate with a certain amount of accuracy the condition of the remainder in each particular section. In the subsequent tests other boilers would be chosen, so that all the boilers would, in time, undergo the test. In a large land installation a certain percentage of the total number is selected for the test. This wear and waste test is technically known as the "drill test." We will now explain, in some little detail, the method of procedure in "water testing" and "drill testing" the chief types of high pressure boilers, and the useful information obtained from the tests.

The most important factor to be noted during water tests of tank boilers is the amount of deflection of the various parts of the boiler, and whether such deflection is permanent after the test pressure is allowed to fall. Before applying the test, deflection meters, with the pointers set at zero, are arranged in the combustion chambers, furnaces, and any other part deemed necessary; the meters being placed in such positions that a good general idea of the condition of the whole boiler is obtained. In a four furnace cylindrical boiler for instance, the meters are set in each furnace at equi-distant angles to each other, and meters are also arranged in the combustion chambers, from back to back, side to side, and bottom to top. As the pressure is applied the meters are observed, and any deflection, either compression or expansion, is carefully noted. When the test pressure is reached the tube ends are examined for leakage, and all seams, especially at the throat of the furnaces, carefully scrutinised. The pressure is now carefully allowed to fall and the meters observed. Should there be any permanent set it should be noted for future reference. With cylindrical boilers the large steam stop valves employed sometimes give trouble, and distort at the high pressures when screwed hard down. Should this occur, the water at high pressure will escape through the valves in the steam pipe, and the test is rendered useless. In such a case the stop valves must be gagged. A most efficient method of doing this is to remove the valve, and insert over its face a sheet of india rubber or insertion; the valve being then replaced and screwed down hard on the material, thus making a watertight joint. This method is much quicker than blank flanging.

The chief point to be observed when testing water tube boilers is to notice any distortion of the tubes when the test is applied. In boilers fitted with straight tubes, a wooden batten is made with one perfect straight edge, and as the test is applied the batten is tried on the fire row of tubes to note any distortion up or down, and also whether such distortion is permanent. The first row is selected as being the one most easily accessible, and also on account of the greater tendency of the tubes in this row to distort. When water testing water tube boilers fitted with curved tubes, as in the case of the Normand type, careful observation must be kept, and any change of configuration of the tubes must be noted. All hand hole door joints must be inspected for leakage, as must also all tube connections. With new door joints a very slight water leak is immaterial, as these joints take up when tightened as steam is being raised. Should special methods be adopted to allow for contraction or expansion of the various parts at varying temperatures, these arrangements should be

free when the test is applied. In testing either type of boiler it must be borne in mind that the test pressure must only be kept on long enough to allow the proper observations to be made, otherwise permanent sets might obtain, and the boiler suffer in consequence. A careful record is kept of each test. with the date, amount of permanent set, if any, and test pressure applied.

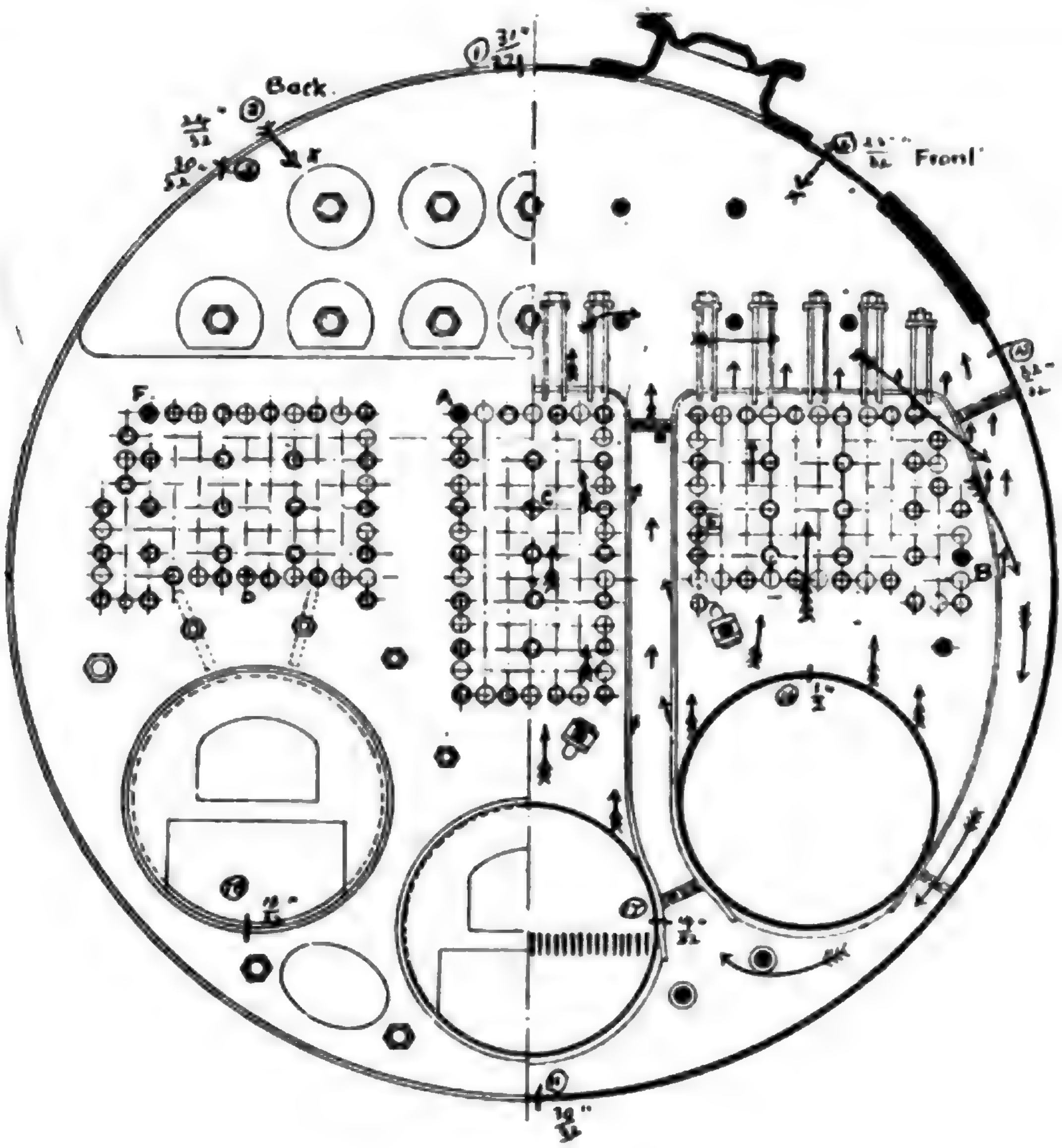



FIG. 1.—CYLINDRICAL RETURN TUBE BOILER.
Drill Test. Letters denote tubes drawn.

We will now consider the drill test of a cylindrical water tube boiler, as this is perhaps the most common form of tank boiler in general use. The boiler is first emptied, dried out, and all doors removed. An examination is then made of the internal surfaces, and any signs of wear, corrosion, deposit, etc., is noted. The zinc protecting slabs and their attachments are then examined, and their condition, as to contact, excessive wear, etc., observed. The boiler is now thoroughly cleaned internally by the usual method, and a part of the outside lagging casing removed for examination of the boiler shell. After cleaning the shell is drilled. It is usual to drill 4 holes in the steam space, at top, side, back and front, and 3 holes at the water line, front, back and side. Below the water level 4 holes are drilled, at back, front side and bottom. Should two boilers of equal age be under test at the same time, half the number of holes are drilled in each, in such positions, that the required information is obtained.

Six tubes are then removed, of which two should be stay tubes, the tubes cut out being selected so as to give a good general idea of the remainder. Holes are drilled in the furnaces and combustion chambers at top, bottom, sides and back, the same procedure being adopted as before described, should two boilers be under test. The tubes removed are then cleaned by the acid bath or by sand blast, cut into measured lengths and weighed, their weights being compared with the original weights. The depth of the pitting is then measured by micrometer gauging, and the wear accurately ascertained. The tube plates are then gauged, and the results compared with the originals thickness, and also, if the boiler has been previously tested, with the previous test thickness. All holes drilled are now measured and compared in the same way. It is usual to gauge in 32nds of an inch, and the wear is given in 32nds from the original. The stays in steam space, below water level, combustion chambers, and furnaces, are carefully callipered, and their present size compared with the original, the wear being in 32nds of an inch. It is now usual to drill holes in the uptakes, smoke-boxes, and funnels, and any excessive wear should be noted. The data obtained from the drill test is tabulated, and an estimate is made of the life of the boiler, each part being considered separately. At the conclusion of the test, the test holes are plugged with fine threaded plugs, screwed in from the

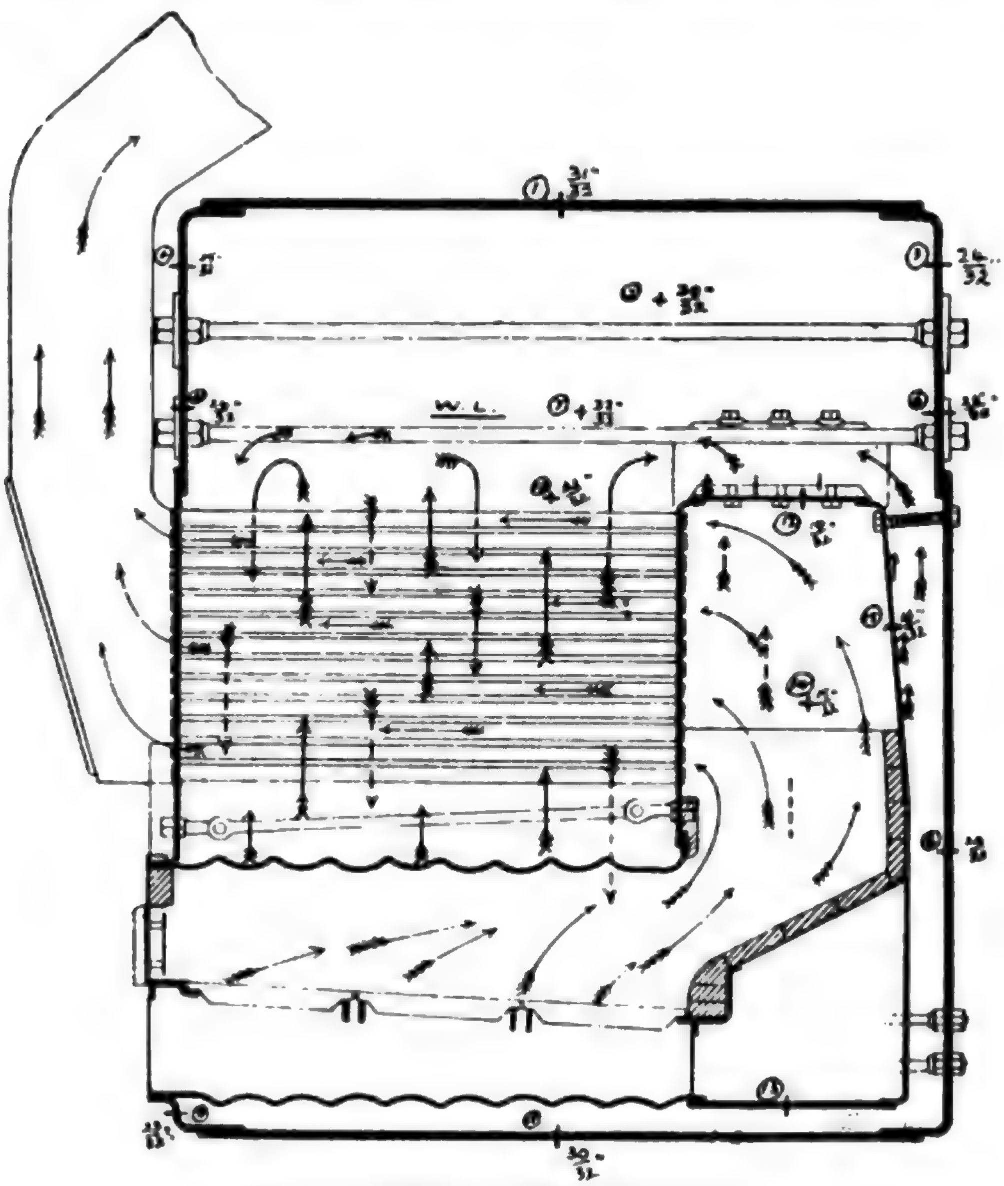



FIG. 2.—CYLINDRICAL RETURN TUBE BOILER.

inside and rivetted over on the outside. The tubes drawn are next renewed, the boiler is closed up, being finally tested by water pressure. As a permanent record of the test a diagram of the boiler is prepared showing holes drilled and tubes drawn. Such diagrams are shown in Figs. 1 and 2, the holes being numbered, and the thickness gauged being noted against each number. The tubes are given either numbers or letters, the letter being the better method. Should two or three boilers be drill tested at the same time, the same diagram is utilised, the holes drilled in the different boilers being distinguished by means of different coloured ink.

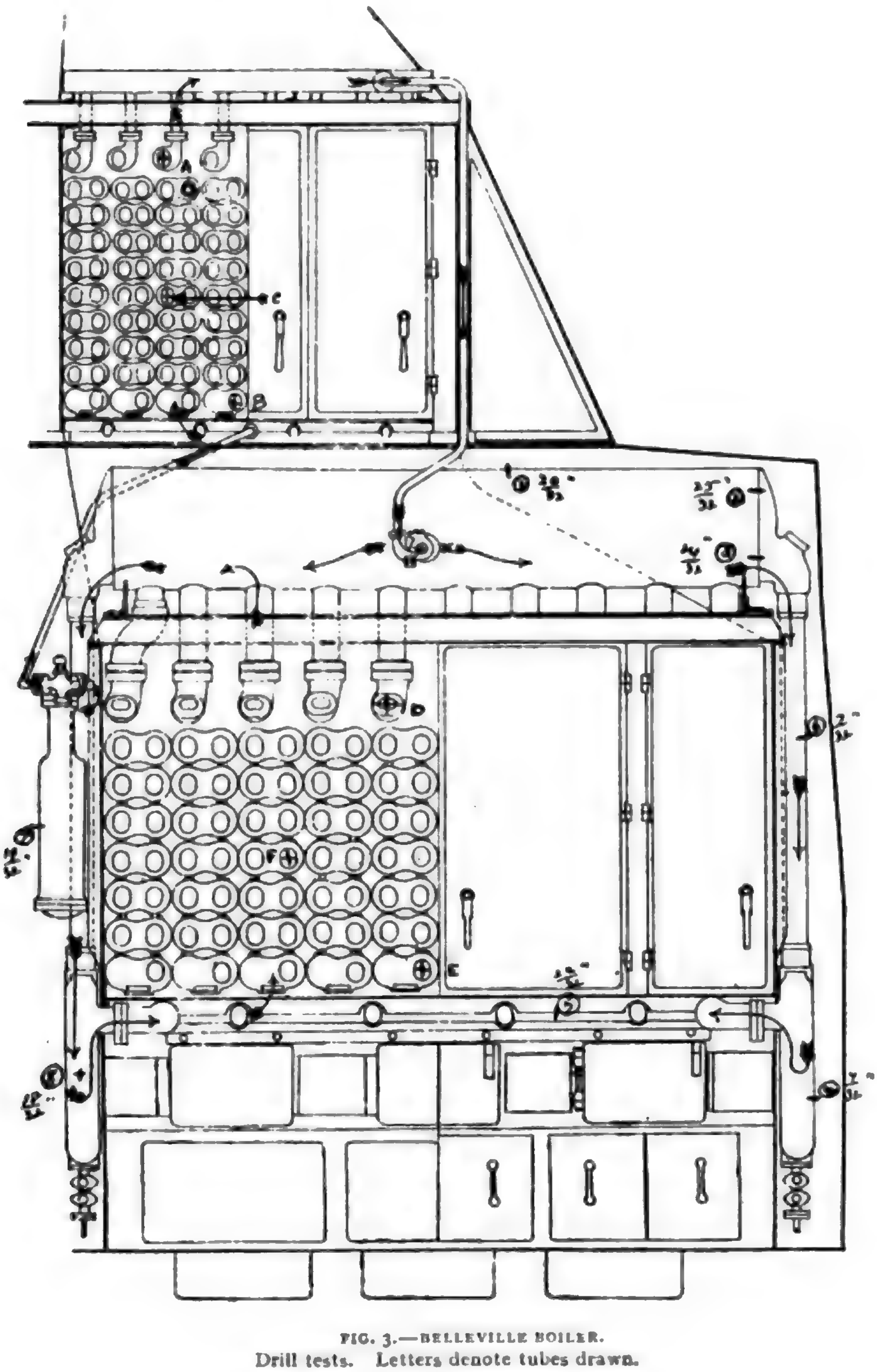


FIG. 3.—BELLEVILLE BOILER.
Drill tests. Letters denote tubes drawn.

The drill test of a water-tube boiler is necessarily a much more complicated matter than the test of a tank boiler. Water tube boilers by the nature of their construction and complicity of parts require a much more extended test, and each particular part requires to be drilled and gauged. The number of tubes removed is usually greater than with a tank boiler, and to give an adequate idea of their condition the tubes so drawn require to be cut lengthways so as to enable a microscopic examination to be made of the water side. The examination and gauging of the tubes is all important, owing to the high pressure the tubes are subjected to, and also the fact that the tubes are thinner than in a tank boiler. It must be borne in mind that in this type of generator the *external* fittings are much more complicated, such fittings as flame baffles, furnace fittings, boiler supports, etc., all require careful examination. Owing to the small amount of water these boilers carry, and the damage that might occur should the feed supply fail, automatic feed arrangements are now universally fitted, and at the drill test these fittings must be disconnected and carefully examined. In connection with this the automatic feed floats should be examined for signs of water-logging. This is usually done by weighing the float and comparing the weight with the original. We will now describe in detail the drill test of the most important water tube boilers. For the purpose of our test we will consider a Belleville boiler of the newest type fitted with an economiser, although of course the general method is the same in the various types of this make. The boiler is first emptied and dried out, and an examination is made of the internal surfaces before cleaning. The internal surfaces should then be cleaned, and an extended examination made. In this type of boiler particular attention should be paid to the condition of the junction boxes, downcomers, and sediment chambers. Holes are now drilled in the steam drum, water reservoir, downtakes, float chambers and mud drums; those holes are drilled at various positions so that a good general idea of the wear of the parts is obtained. The holes are next carefully gauged by micrometer, and the thickness compared with the original thickness. Any pitting discovered should be gauged and noted; this refers to both internal and external surfaces. A portion of the external lagging is now removed and the surfaces examined.

Should it be deemed necessary a certain percentage of the junction boxes should be removed and sawn

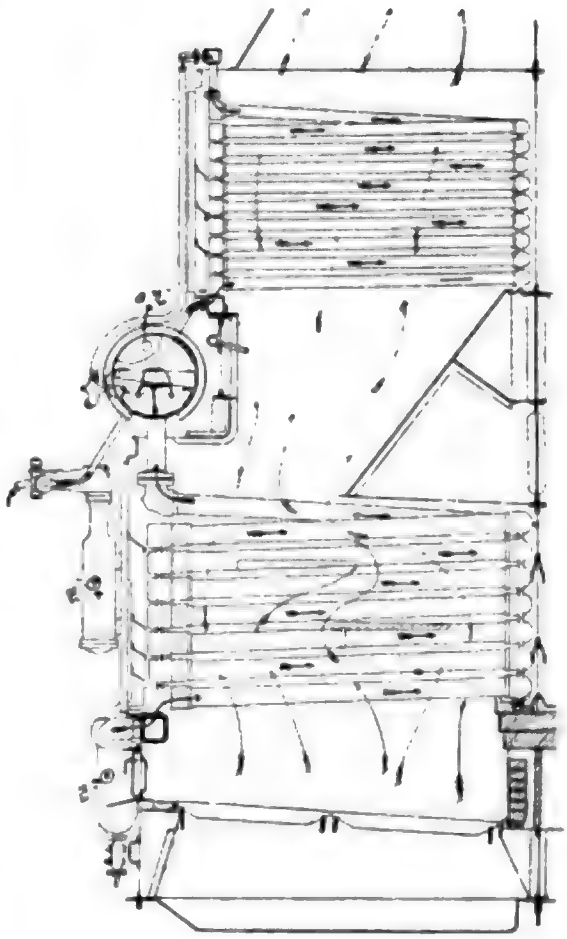


FIG. 4.—BELLEVILLE BOILER.

through without removing the tube. This test shows the condition of the screwed end of the tube and its bearing in the junction box. A certain number of the tubes are now removed, it being usual to remove three tubes from both generator and economiser. In the economiser the top, bottom, and an intermediate tube should be taken out, and the top, fire row, and an intermediate generator tube. When selecting an intermediate tube preference

should be given to a tube which shows signs of more extensive wear than the remainder. Both generator and economiser tubes should then be cleaned by the acid bath, cut up in known lengths and weighed, the weights being compared with the original. Certain portions of the tubes are now cut longitudinally to allow the thickness to be gauged and the condition determined. Should the condition of the drawn tubes show excessive wear, further tubes should be drawn, cut up, and tested. The gaugings are compared with the original thicknesses and carefully noted. The furnace fittings are now examined, flame baffles and boiler brickwork. Should provision be made to allow the various parts of the structure to expand or contract under the varying conditions, the condition of such arrangements must be examined and noted. Finally the boiler mountings are opened out and examined, the test holes plugged, tubes replaced, and the boiler closed up and tested by hydraulic pressure. Test diagrams of a Belleville boiler are shown in Figs. 3 and 4.

In the Babcock and Wilcox boiler the same method of procedure is adopted as regards the generator tubes, but in this

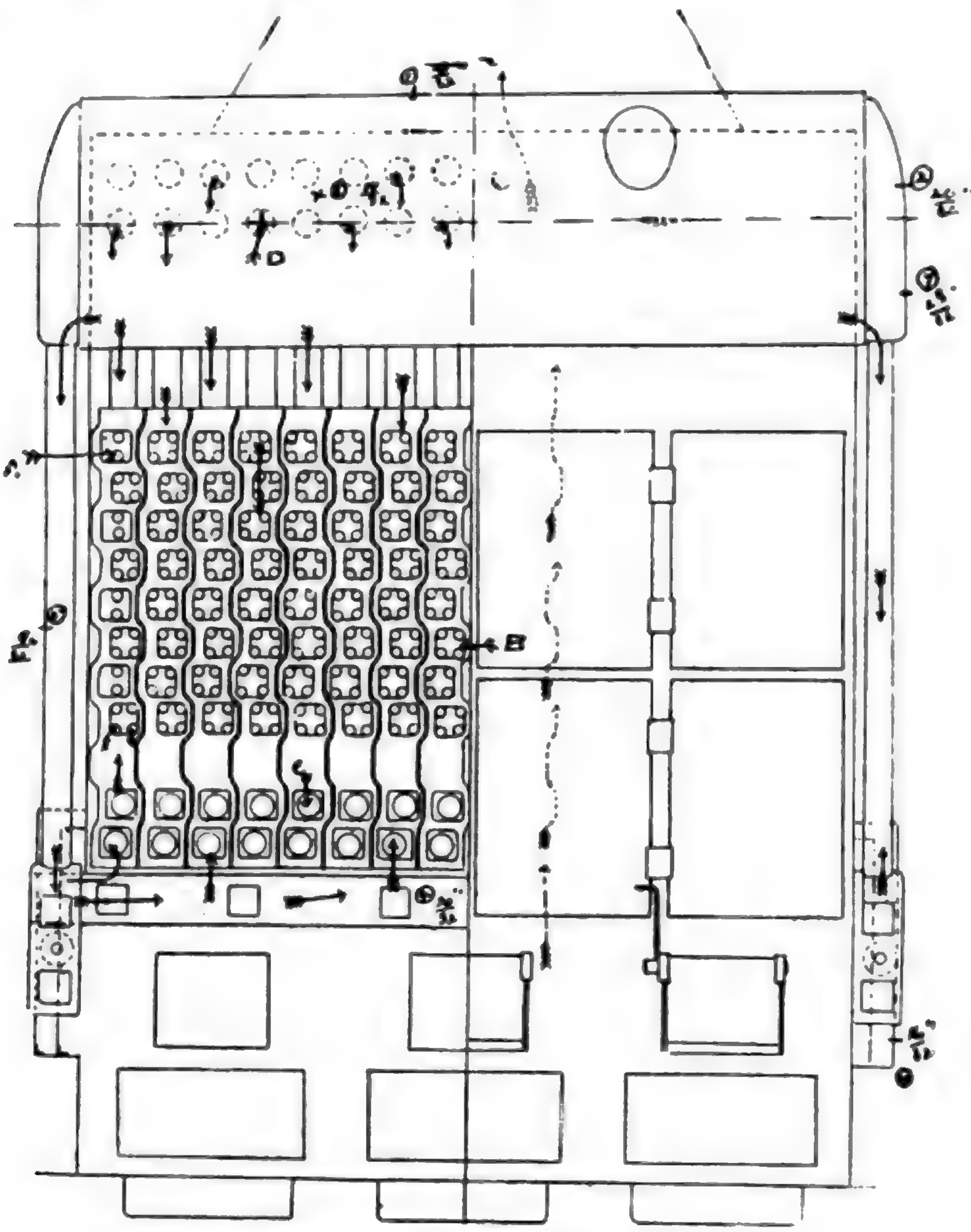


FIG. 5.—BABCOCK AND WILLCOX BOILER. Drill test. Letters denote tubes drawn.

boiler economisers are not fitted. It is usual to draw one return tube at the test, this tube being tested in the same way as the remainder. With this type of generator, the tubes vertically under the automatic feed arrangements appear to wear more than the remainder, and at least one of the tubes so situated should be drawn and tested. Test diagrams of the Babcock and Wilcox boilers are shown in Figs. 5 and 6.

In water tube boilers of the small tube type a rather different method is adopted. We will take for example the test of a White Forster boiler, this being a well-known small tube type. The boiler is emptied and examined in the same manner as in the previous tests. The main steam drum is drilled at front, back, and above and below water line. The lower water reservoirs are drilled, one at the front end, and the other at the pack. If considered necessary two holes are drilled in each lower drum. A complete row of tubes are then cut out, starting from the centre of the drum and working out to the wall or outside row in a horizontal line. This is done in order that a more or less complete estimate of the condition of the whole of the rows can be obtained. On the opposite side a tube is cut out from the fire row, and one from the wall row. The holes drilled, and the holes from which the tubes have

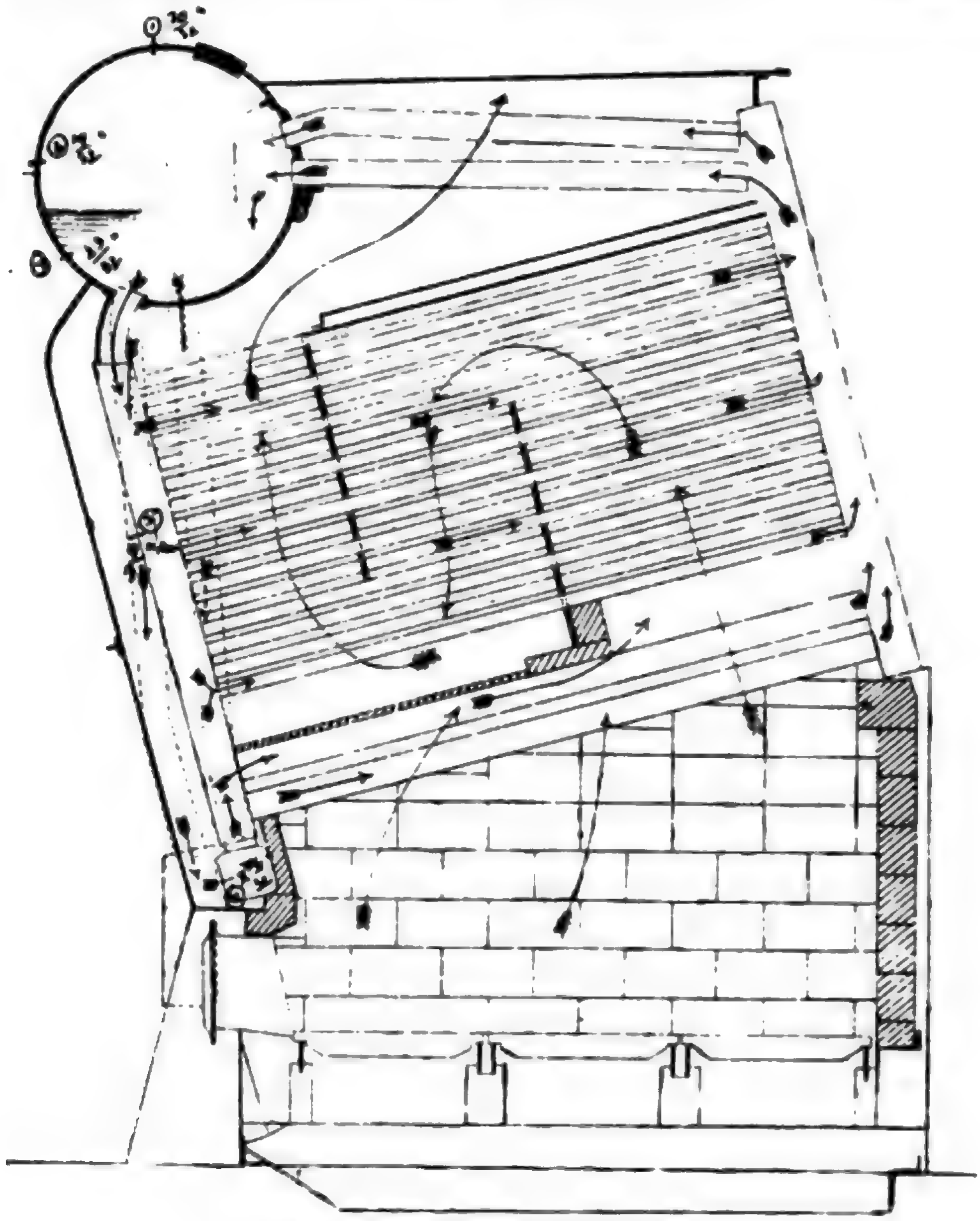


FIG. 6.—BABCOCK AND WILLCOX BOILER.

been taken, must be carefully gauged and noted for comparative purposes. All the drawn tubes are tested as in the previous tests described. Lagging is next removed from the steam and water drums, and the condition of the surfaces carefully examined. The lower drum supports or bearings are then carefully examined. As the brickwork is an important factor in this class of boiler, particular attention must be paid as to its condition. Casings, baffles, and uptakes are all in turn inspected. The zinc slabs in the steam drum are carefully examined, and if necessary, renewed. This point is important, as should flakes of zinc drop, it might cause a tube to become choked, with the consequent danger of overheating. Before the tubes are cut up, it is a good plan to compare their slight curvature with a new row of tubes, in order to detect any signs of distortion.

The test is completed on the lines indicated with the other type. In view of the increasing favour with which the Yarrow large tube boiler is being regarded, especially in naval circles, it might be mentioned here that the generator is tested in an exactly similar manner as the White Forster. Fig. 7 shows test diagram of a White Forster boiler.

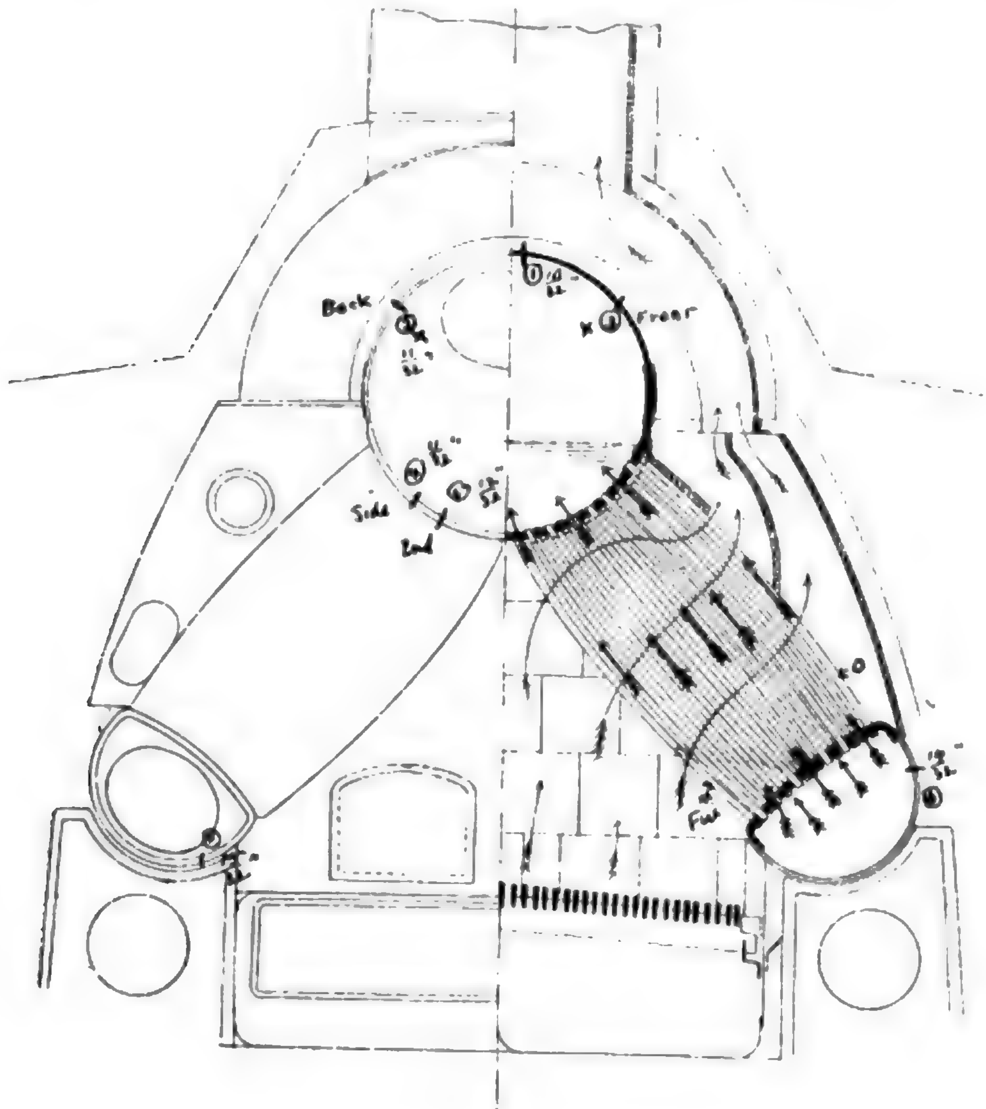



FIG. 7.—WHITE FORSTER BOILER.
One row of tubes drawn from fire to row O.

The importance of the water and drill tests of modern steam generators cannot be overestimated, as upon the care taken with these tests, the efficiency as well as the life of the boilers depend, and last, but not least, the safety of the persons attending them.

# A PROPOSED PLANT FOR THE PRODUCTION OF CHEAP POWER

**By James Hill, Assoc. M. Inst. C.E.**

Although steam boilers have been fired by the waste gases from blast furnaces for a great number of years, people have hesitated to put down producer plants specially to make gas for raising steam. However, since the introduction of the Mond and other similar processes for recovering sulphate of ammonia from producer gas, it has been found in some instances to be a commercial proposition to put up with the loss in gasification owing to the compensations from the value of the sulphate. The difficulty has hitherto been in finding a type of boiler really adapted for gaseous firing. Apparently the problem has been largely solved by the discovery of flameless combustion, and in the present article Mr. Hill has pointed out the possibilities of a combination of a modern producer plant, and up to date ammonia recovery appliances with a really efficient type of flameless boiler and an economical type of steam engine like the Uniflow. It will be extremely interesting if the results he deduces from the combined efficiencies should be borne out in practical working. If this should be so, the steam generating station would appear to still have a prosperous future before it.

THE search for a plant of high thermal efficiency offers an interesting field of study and wide scope to all engineers, and is important from a commercial as well as a scientific standpoint.

There is always great difficulty in choosing generating plants that will give high efficiency for units of, say, from 200-800 B.H.P., and most stations cannot have their generating plant in one large unit with one spare owing to the high first cost and limited flexibility of efficient working.

In the following article a plant is described which seems to be an advance in the right direction. It is proposed that this plant should consist of a producer gas plant with ammonia recovery plant attached, surface combustion gas fired boilers and "Uniflow" steam engines, these three efficient generators being combined to produce an apparatus of high efficiency.

With this proposed plant efficient results could be obtained in single cylinder units ranging from 200 to 2,500 B.H.P., and higher still by utilising the generated steam in large steam turbines. Producer gas is manufactured on a large scale with entire satisfaction, and a class of fuel can be used which would not be suitable for consumption in coal fired boilers without the aid of induced or forced draught, owing to the high percentage of ash present.

The ammonia recovery plant is a great asset, as the value of the sulphate of ammonia recovered considerably reduces the plant charges. A plant capable of gasifying 60 to 100 tons of fuel per 24 hours would cost as follows :—

| | Per ton. s. | d. |
|---|---|---|
| *Charges.*—Fuel .. .. .. | 10 | 0 |
| Wages .. .. .. .. | 1 | 6 |
| Steam .. .. .. .. | 2 | 0 |
| *Stores.*—Repairs and maintenance .. .. .. .. | 0 | 6 |
| Sulphuric acid.. .. .. | 1 | 3 |
| Bagging sulphate of ammonia | 0 | 3 |
| Total .. .. | 15 | 6 |

*Credit.*—90 lb. of sulphate of ammonia per ton of fuel at £13 per ton=10s. 5d., leaving the nett cost per ton of fuel=5s. 1d.

A well-chosen bituminous coal with a low percentage of sulphur, and fairly high percentage of nitrogen is required.

An average analysis of a suitable coal gives 5% water, 80% combustibles (of which 50% is fixed carbon and 30% volatile matter) and 15% ash. This coal has an average calorific value of 11,000 B.T.U.'s per lb. The amount of sulphur in the

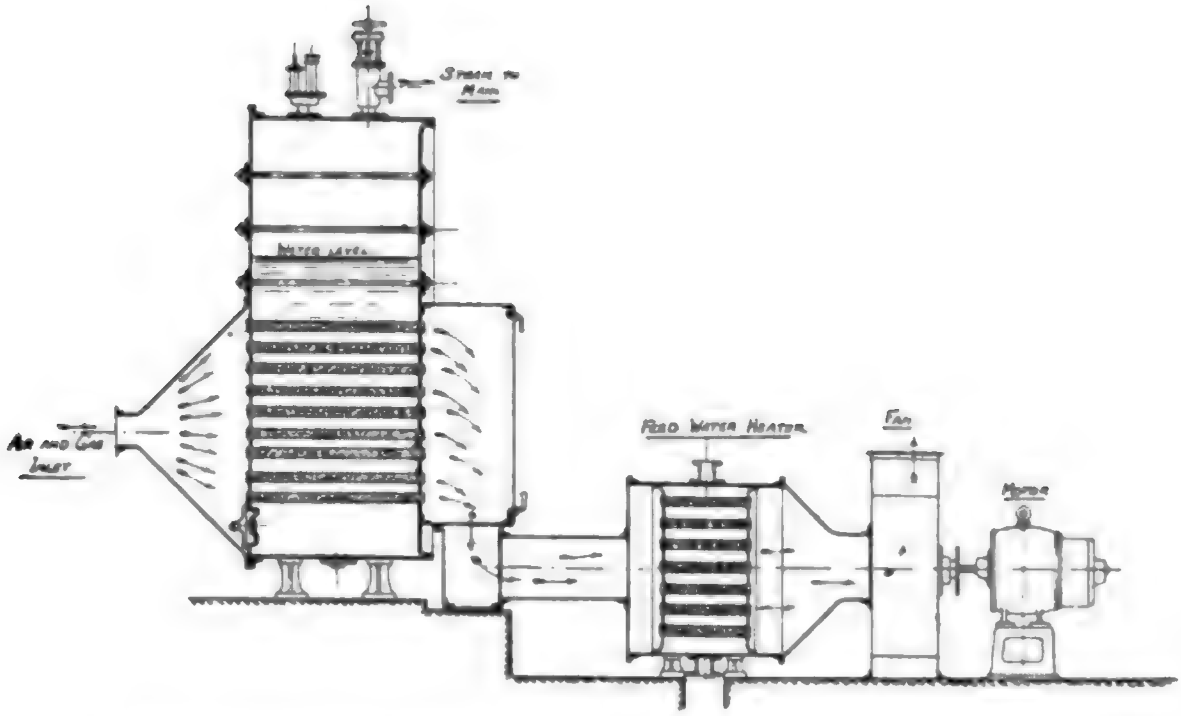



FIG. 1.—"BONECOURT" MULTITUBULAR BOILER. CAPACITY 5000 LB. OF WATER PER HOUR.

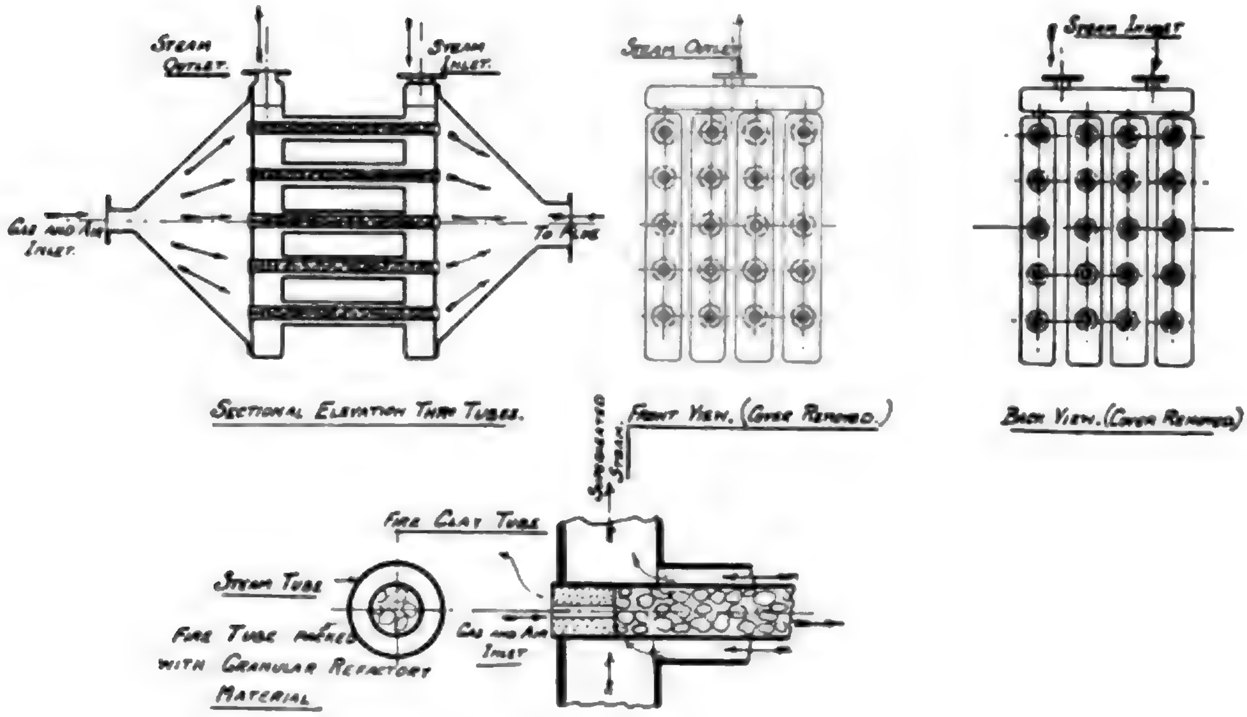



FIG. 2.—GENERAL ARRANGEMENT OF SUPERHEATER.

coal should not exceed 2% and the amount of nitrogen not less than 1·5% of the combustibles. The yield of sulphate of ammonia entirely depends upon the nitrogen in the coal; but about 80% of the theoretical amount present should be recovered. The gas obtained has an average calorific value of 145 B.T.U.'s per cubic foot (lower value) and the amount of gas that can be obtained from 1 ton of fuel is 140,000 cubic feet at N.T.P. The composition of the gas produced varies slightly, but the average is as follows :—

| | |
|---|---|
| Carbon dioxide .. .. | 17% |
| Oxygen .. .. .. | 0% |
| Hydrogen .. .. .. | 27% |
| Marsh gas .. .. .. | 3% |
| Nitrogen .. .. .. | 43% |
| Carbon monoxide .. .. | 10% |

The steam required for the producers absorbs 15% of the total heat of the coal, and the auxiliary plant, which includes blowers, pumps, washer, motor, etc., absorbs another 2%. The nett thermal efficiency of the producer plant is, therefore, 65%.

The consumption of the gas in suitable boiler furnaces has hitherto not been very successful without the application of elaborate re-generating furnaces, but the introduction of flameless combustion has removed this objection. It is possible with this system, in a specially constructed boiler taking up only one quarter of the space occupied by an ordinary coal fired Lancashire boiler, as manufactured by Messrs. the Bonecourt Surface Combustion Co., Ltd., to obtain exceptionally high thermal efficiency.

Surface combustion, in this form of boiler, is a practical development of Sir Humphrey Davey's experiment, in which it was found that a whitehot

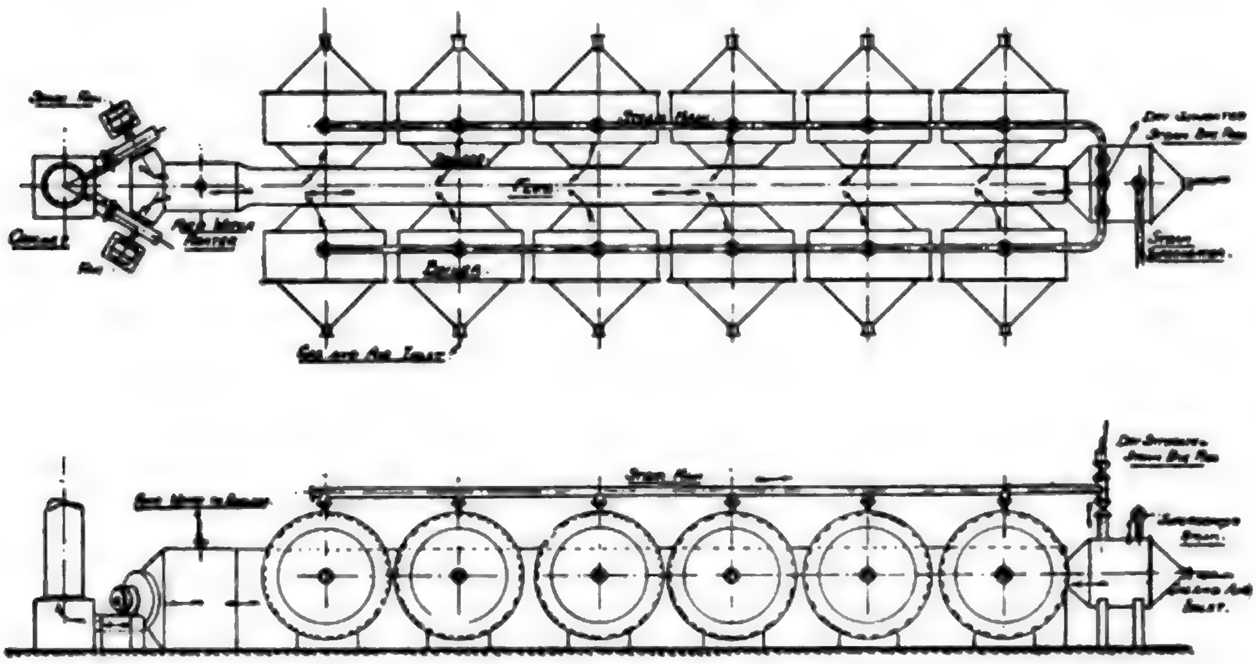


FIG. 3.—BOILER PLANT FOR 5,000 B.H.P.

platinum wire held in an explosive mixture of gas and air still remained white hot. The usual smoke tubes are converted into the fire tubes in this type of boiler, and are filled with granular refractory material through which the mixed gas and air is drawn by means of a fan. The refractory material having once become hot the gas and air no longer burn with a flame, but are consumed flamelessly. It is found that combustion takes place very rapidly and is complete before the gases have traversed one foot of length of the tube. This, of course, shows that the temperature at the front end of the tube is very high (about 2,700° F.), and at the back

end, in a boiler generating steam at 170 lbs. per sq. inch, about 425° F. The large drop in the temperature along the tube causes a violent circulation of the water in the boiler, and it has been found to reduce the tendency of scaling to a minimum after long periods of running with water not altogether pure.

The front end of each firing tube is fitted with a fire clay plug about 4 ins. long with a $\frac{3}{4}$ in. diameter hole in the centre. This plug tends to keep the front end of the tube, which is not in contact with the water, owing to passing through the tube plate, comparatively cool, and also speeds up the velocity of the gas and air coming in from the mixing chamber, and thus prevents the tendency to back fire.

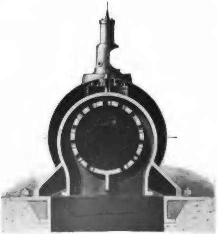


Fig. 1 shows the general arrangement of a boiler capable of evaporating 5,000 lbs. of water per hour. The boiler is very short, the firing tubes being only 4 feet in length, and in larged sized units it would only be necessary to increase the diameter of the boiler, as the fall in temperature along the tube would be exactly the same. The thermal efficiency of this boiler, after deducting the amount of power required for the fan, and including the feed water heater, was 90%, which is considerably higher than any type of coal fired boiler can show. As the

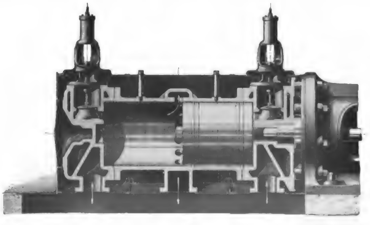


FIG. 4.—LONGITUDINAL AND CROSS SECTIONS OF A SULZER UNIFLOW STEAM ENGINE. 350 B.H.P., 150 R.P.M.

temperature of the exhaust gases is so low it is not possible to generate super-heated steam by these gases, but a feed water heater is provided, the tubes of which are filled with the same granulated refractory material as the tubes in the boiler.

To super-heat the steam made by the boiler, it is necessary to use a separately fired super-heater as shown in Fig. 2, and this super-heater can be self-regulating with a thermostatic valve. The loss of efficiency owing to this separately fired super-heater is 10%, but super-heated steam is not absolutely essential in this type of engine, as it is claimed by " Stumpf " that there is little to be gained by its use ; thus reducing the nett efficiency of the boiler, including the superheater to 80%.

Fig. 3 shows the proposed arrangement of a suitable boiler plant for 5,000 B.H.P., allowing two boilers as spare. The boilers are shown back to back with one common flue running through one feed water heater ; the gases being drawn away by two fans (one spare) and taken away by a short stack. The steam is shown gathered into a trunk main, which can be bye passed at will through a separately fired super-heater (Fig. 2). The nett thermal efficiency of this boiler and super-heater surpasses all other types of coal fired boilers by, at least, 10%, moreover, the plant requires less attendance.

The sulphur in the furnace gases in the form of sulphur dioxide combines with the water of combustion to form sulphurous acid, and also small quantities of sulphuric acid. The amount of sulphur in the coal must, therefore, be kept as low as possible to avoid serious corrosion. The gas need not be absolutely free from tar, as any tarry matter could not remain in the fire tubes owing to the high temperature.

The Uniflow steam engine, as the name suggests, utilises the steam by keeping up a constant flow in the cylinder from high pressure at each end of the cylinder to vacuum at the centre, where the exhaust takes place, and so reduces the condensation loss to a minimum ; in fact, it is claimed to be absolutely absent ; whilst in the

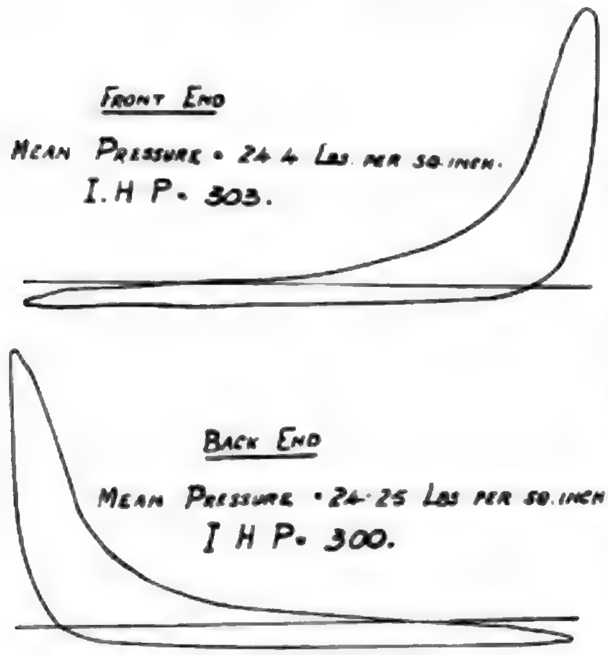



FIG. 5.—INDICATOR DIAGRAMS FROM SULZER UNIFLOW STEAM ENGINE. DIAMETER OF CYLINDER 26⅜. STROKE 31½. SPEED 142 R.P.M. STEAM PRESSURE 170 L.B. PER SQ. INCH. TEMPERATURE OF STEAM 600° F. VACUUM 28.5 IN.

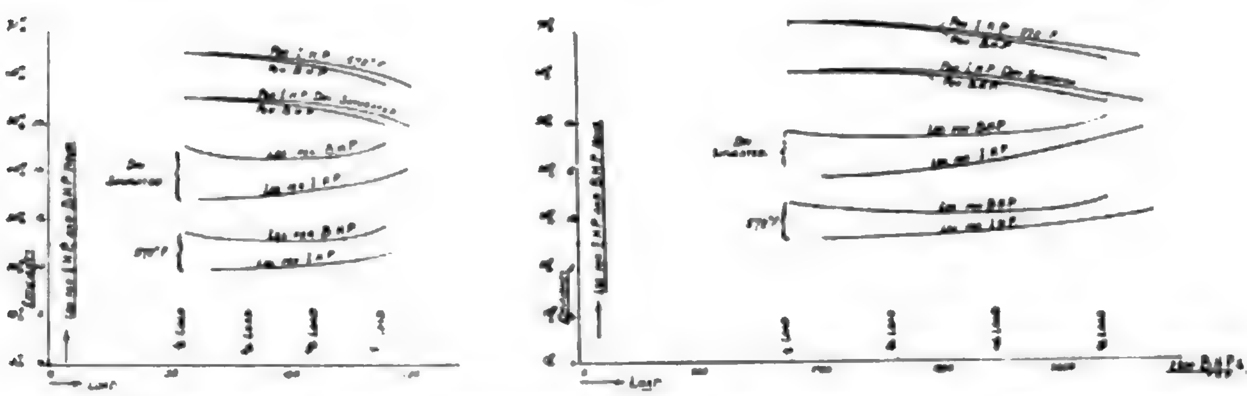


FIG. 6.—APPROXIMATE THERMAL EFFICIENCIES AND STEAM CONSUMPTIONS OF THE UNIFLOW ENGINE. STEAM PRESSURE = 170 LB. PER SQ. INCH AT ENGINE STOP VALVE. VACUUM 28.5 IN. INJECTOR WATER TEMPERATURE 54° F.

alternating flow type of engine, condensation takes place to a marked degree. Fig. 4 illustrates the general appearance, and cross section of a Uniflow steam engine, as built by Sulzer Bros. It will be seen from the section that the steam inlet valves are fixed in the cylinder heads, and the exhaust ports, which are of four times greater area than the area of steam inlet, are placed in the centre of the cylinder; being conducted into a chamber communicating with the condenser. The cylinder heads are so constructed that a portion is utilised as a receiver, while the other portion is used to increase the compression space when starting up the engine, or when exhausting to atmosphere; this extra allowance is communicated to the cylinder by a valve manipulated by hand. The cost of maintenance of this type of engine is exceedingly low. The cylinder in this illustration is un-jacketted and is constructed for use with super-heated steam, but, where saturated steam is used, the cylinder is jacketted for a portion of its length at each end.

The indicator cards (Fig. 5) show clearly the action of the steam in the cylinder, and the expansion and compression curves on these cards are almost adiabatic.

Fig. 6 shows the efficiency, and consumption curves for "Sulzer" Uniflow steam engines from 200 to 2,500 B.H.P.

These figures include the power used in the condensing plant, and it will be seen at a glance that they compare very favourably in the small sized units with triple expansion engines of larger size. They relate to single cylinder units only, but it would be possible to combine two single cylinder units into a twin engine to increase the capacity of the units to 5,000 B.H.P. The power required for other portions of the condensing plant, such as feed pumps, etc., would be about 5% and the mechanical efficiency of the engine 90%. Combining the thermal efficiency of these three systems, namely, 65% for the producer plant, 80% for the surface combustion boiler (including super-heater), 51½% for the small engine and 56% for the larger units—the nett thermal efficiency of such a plant would be 26¾% for the small engines and 29% for the larger engines. This latter figure expressed in heat units recovered from the coal is equivalent to 3,190 recovered out of 11,000 present, which is a decided improvement upon any existing generating plant running on a commercial scale.

# UP-TO-DATE METHOD OF BUTT-WELDING TUBES

**By Chas. H. Wall**

THIS improved method was adopted as a means to increase and cheapen the production of tubes over the old systems of back-ending and fore-ending, and the bell-welding as worked with the tags attached to the strip.

This latest method of butt-welding came from the United States about 10 to 12 years since, aud practically is mechanical from start to finish, manual labour taking a very small part excepting in directing the various machines through which the tube passes in the different stages of manufacture. The initial cost and outlay of a fair size plant somewhat prohibits its adoption by small and medium size firms, especially as small plants under this system work with less economy, and again to get the greatest production at the minimum of cost it is necessary to work day and night, and thus large firms have another advantage, as they generally are in a better position to do this.

A one furnace plant, or one unit as it may be termed, produces somewhere about three to four times more tubes than one coal-fired furnace could under the old system. It must, however, be borne in mind by way of comparison that it is a gas-fired as against a coal-fired furnace. The gas-fired furnace is of much larger capacity, and were it not for the mechanical arrangements in handling the tubes it would be practically impossible for human beings to stand the wear and tear of handling the tubes produced by this type of furnace. There is a limit to human endurance, especially with the welder in this system. There are generally three welders to each furnace working in turns, so long on and so long off. The heat is simply overpowering; each man as he takes his turn wears blue glasses to protect his eyes, a shield to protect his face and head, whilst a fan is employed blowing a current of cold air across the front of the furnace to enable him to get close up when fixing his tongs on to a strip inside the furnace which may be ready for welding. The furnace of one unit plant is generally supplied by one or more gas producers, of the water-sealed continuous type, it being found in practice that producers in series work better than a large one of equal capacity. The producers may be fixed a distance away from the furnace in a convenient place which is often ruled by local conditions, the coal supply and handling having to be considered with their advantages or disadvantages as the case may be. The gas, of course, is carried by flues underground or overhead which ever way may be most convenient.

The furnace generally adopted is of the cross-fired type fitted with gas and air valves made reversing, and one main valve for regulating the supply of gas; and by means of regenerating chambers underneath the greatest economy is obtained from utilising the waste heat. The length of the bed should be such as to enable it to deal easily with the length of tube it is intended to make; in fact, a foot or two to spare will be found an advantage. The strip is delivered to the end called the charging end, a machine here shears off the corners of the strip to shape (Fig. 1) prior to its being charged into the furnace, the object of this being to enable the strip to lead easily into the welding bell, this lead

giving a gradual turn from the flat into the tube as it passes through the bell-shaped die. (Fig. 2.)

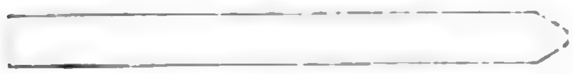


FIG. 1.—SHEARED STRIP.

The bed of the furnace is wide enough to take 18 to 20 strips of some sizes side by side; this number varies according to the diameter and size of the tube, being less for the larger sizes. As one is drawn and welded from the furnace a fresh strip is charged into its place. The length of

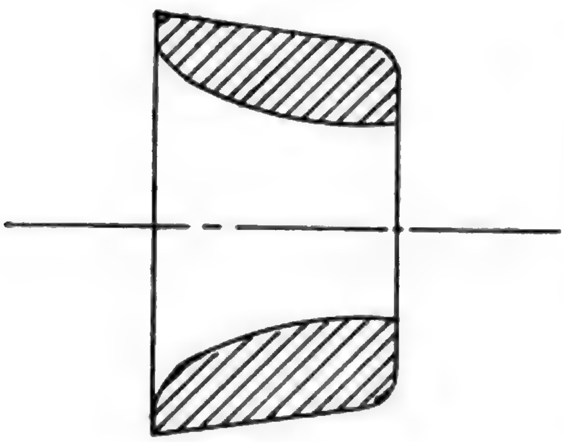


FIG. 2.—WELDING DIE.

strip used may be anything from 20 to 25 feet long. As soon as the first strip is ready for welding, the welder fixes his tongs (Fig. 3) on to the bevelled end of the strip, the nose of which, previous to charging into the furnace, is set up by the machine when shearing off the corners; the object of this is to ensure the welder pushing his tongs easily

FIG. 3.—SPECIAL WELDING TONGS.

and surely on to the strip before closing the reins. He then passes the die (Fig. 2) over the tongs, these being so constructed that when closed in the grip they pass easily through the die, the end of one rein being formed into a cylindrical knob with a slot on the one side into which the other rein fits whilst the grip is on the strip, and so held by the spring resistance of the reins. This knob forms an easy means of connection with the wagon which has a slot in the front bar, into which it is dropped by the welder; the wagon runner then drops the dog into the draw bench chain, and thus the strip is drawn from the furnace, turned and welded into a tube at the one operation. As each strip is welded the drawbench is moved on to the next, the bench working radially from gearing at the front end, and thus travelling backwards and forwards to each strip as it lies in the furnace which ensures a straight pull out.

The tube is delivered from the bench on to skids down which it rolls into a trough; at the same time the weld is examined as to its soundness. If not properly welded the tube is thrown out, if sound it passes from this trough to the sizing rolls. These rolls ensure all tubes to be of the same diameter, the wear on the rolls being less in proportion to the work done, than is the case with the welding dies.

The tube is passed from the sizing rolls by means of a covered trough through the cross or straightening rolls where it enters a trough covered with a hinged lid; this lid is actuated by means of balanced levers, the operator by pressing down the lever lifts the lid, the tube rolling out on to the skids or cooling rack. From here the tubes are taken one at a time when cool enough to handle, examined as to their straightness and facial defects, and if not straight are sprung so through a block.

The springer after passing each tube drops it into cradles in quantities of 15 cwt. to 20 cwt.; these cradles are moved on by means of an overhead single run electric crane to the screwing machines which are of the automatic or open die type and fitted with cutting off arrangements. Here the tubes are squared on the ends before screwing, a sufficient number of cradles being necessary (two to each machine) for conveying the unscrewed tubes to, and the screwed tubes away. As one cradle is unloaded, another full one

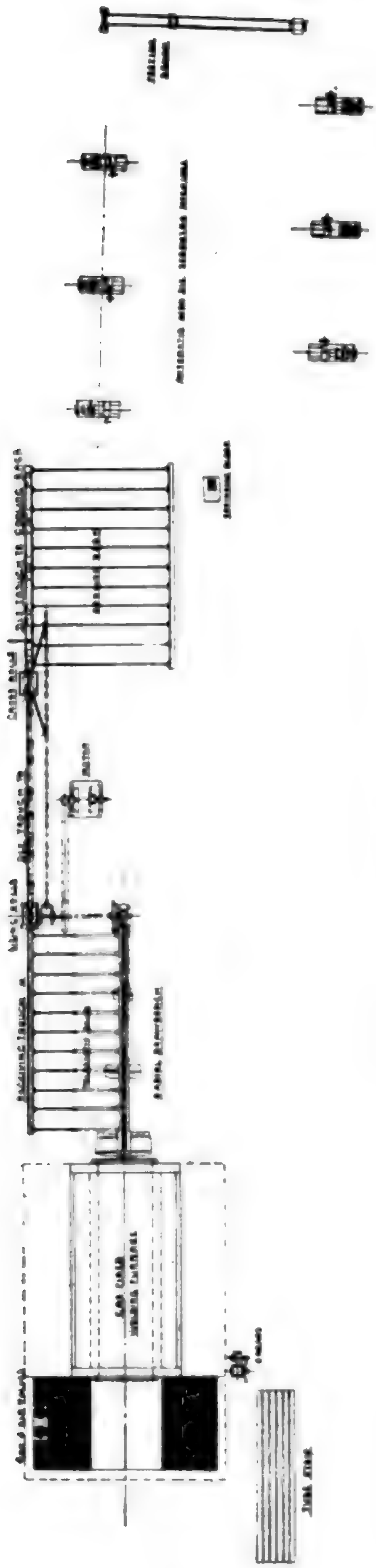


FIG. 4.—PLAN OF UP-TO-DATE BUTT WELDING MILL.

takes its place and so the tubes after screwing are carried away to the proving benches by the same crane where each one is tested to 5 or 600 lb. water pressure per square inch, this pressure being generally maintained by pumps and accumulators set to the pressure required. The construction of the proving benches is so arranged that as each tube is inserted between the heads it becomes charged with water from a separate supply, from a tank or reservoir with a head sufficient to fill the tube quickly, and by the operation of cocks this supply is closed, and the pressure from the accumulator turned on; this plan is generally adopted for medium and large size tubes, the smaller tubes being usually filled direct from the accumulator. The head of the proving pump is cylindrical, and inside of it is a specially designed piston and valve which travels forward to make the joint on the end of the tube, at the same time charging it with the water under pressure; the head at the other end being fitted with an air tube escape and adjustable to suit the varying lengths of the tubes. The head is held in position by a lever of a simple and quick action construction. A gauge registering the pressure is fixed to the charging end for the guidance of the operator. Imperfect welding, split ends from screwing and other defects are generally exposed by this test, the tubes with such are marked and thrown on one side.

Since the introduction of electric driving, which is so easy of division into units, the chance of stoppages has been reduced to a minimum. In a thoroughly well designed works with electric driving the efficiency has greatly increased, as compared with the old system of driving, by means of a steam engine, all the different departments as one unit, especially as some firms have been loth even to modernise their engines; some of the worst types are still to be found in these mills, probably having been good friends in the days long gone, they are still retained, but are not so economical as their offspring of a later generation.

# THE MECHANICAL HANDLING OF COKE FROM COKE OVENS

By G. F. Zimmer

*Conclusion*

STOLE, of Farlowitz, in his latest coke plant (Fig. 28), has adopted a water trough or canal, similar to the installation shown in Fig. 25, but the canal is not for quenching purposes in this case, but to float the hot coke receptacles, like boats, to the quenching tower, a power-driven water wheel creating the necessary current for the conveyance of the coke receptacles. The *modus operandi* is as follows :—A floating receptacle is placed in front of the oven to be pressed, which receives the charge which is superficially quenched under a water spray. The vessel is now released and the final quenching proper is not performed until the floating skep reaches the quenching tower *a*, here it is emptied on to a grating *b*, and completely quenched by the quencher *c*, the shute *d* is now lowered and the coke is raised by the lift *e*, either for classification, or into railway trucks, leaving the breeze beneath the bar screen. Since the skeps float rather deeply in the water, they do not suffer to any great extent from the hot coke. So far this system has only been used in gas works, but it is also to be adopted for coke ovens.

Lastly, we have to deal with those appliances for which there is no hearth necessary at all, and in which quenching, sifting and loading is performed as a continuous process. An installation of this type is that of " Meguin " (Fig. 29 ; ) the machine is mounted on wheels and runs along the front of the ovens on rails. The coke is pushed past a long quencher *a* (consisting of a network of spraying pipes), and over a sloping shute into a hopper *b*, through the adjustable spout of which the coke falls on to a travelling band *c*, the lower terminal of which dips into a water

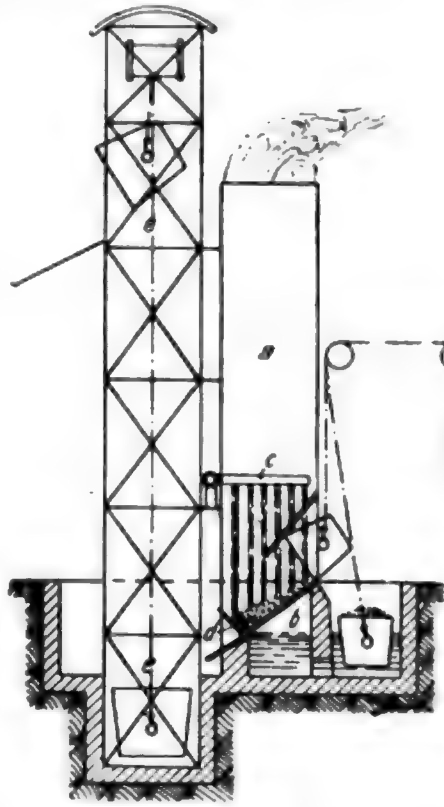


FIG. 28.—THE COKE HANDLING SYSTEM OF STOLE OF FARLOWITZ.

tank *e*, so that the coke is thoroughly quenched on its way to the screen *d*, which delivers the large coke on to a shute leading to the railway truck, whilst the screenings are discharged

into a special hopper. The overflow water from the quenching tank runs into a drain extending the whole length of the battery, the tank being replenished with water from a trench *f*, by means of a centrifugal pump *g*, coupled direct to the motor operating the machine. Since the conveyor *c* is consists of an inclined conveyor delivering the coke to a screen forming a part of the machine and loading it direct into trucks. The coke is exposed to the action of a quencher, and the work is afterwards completed while on the conveyor by additional jets. The sections of the conveyor are made of perforated

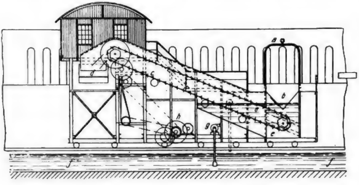


FIG. 29.—SHOWING THE PORTABLE QUENCHING, SIFTING AND LOADING MACHINE OF MÉGUIN.

sufficiently long to hold a full charge from one oven, the machine, when filled, can be run to any part of the track for discharging into trucks, so that all shunting is dispensed with. For blast-furnace work, the machine discharges into hoppers, from which the charging skeps can be loaded.

A modified form which was successfully installed at the cokery of the Soc. des Mines de Béthune, Bully, (Fig. 30) sheet-iron, with side plates 12 in. high. The conveyor consists of three chains connected to each other by cross pieces, and a narrow gangway for the attendants is provided on either side of the conveyor. The delivery end of the machine is provided with a jigging screen, and the whole of the installation is mounted on a substantial frame running on wheels in front of the battery. The quencher and loader is

FIG. 30.—THE MÉGUIN MACHINE AT THE COKE WORKS OF THE MINES DE BETHUNE IN BULLY LES MINES.

moved from one oven to another by a slewing crane, operated from the main motor by ropes; and a contrivance with intermittent motion, between the quencher and conveyor, enables the coke to be spread out for completing the quenching.

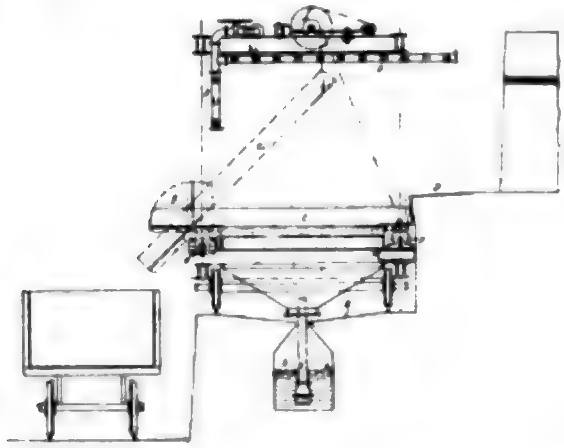


FIG. 31.—COKE HANDLING MACHINE OF KELLNER AND FLOTTMANN (SCHUMACHER SYSTEM).

Another somewhat different type is the machine of Kellner and Flottmann, of Düsseldorf, used at the Herne cokery of the Hüstener Gewerkschaft, Fig. 31. In front of the short ramp *a*, and about 6 ft. lower, is a second broader level *b*, with the rail track for the machine. The apparatus like those formerly described is self-contained; the floor, as it were, of the machine, consists of a grating *c*, the bars of which are attached to two frames in such a way that those secured to the frame *c*, can alternately be raised and lowered by means of a roller *f*, whilst the intermediate bars remain stationary. The screen is operated by eccentric shafts, *d* and *e*, on which the screen frames are loosely mounted in guides $c^1$. On the side away from the ovens, the screen has a cast iron hinged extension, *g*, which is lifted up while the coke is being received, but falls down automatically when the screen is tilted, and forms a shute for the discharge of the large coke to the trucks. The screenings fall into the hoppered bunkers of perforated plate in the underbody of the carriage, so as to allow the quenching water to escape. The quenching water is drawn from a conduit, *h*, below the track through a suction pipe *i*, by means of a centrifugal pump, which delivers the water to a series of sprinkling pipes, *k*, above the screen. The machine deals in each operation with the whole charge of one of the ovens, which may be discharged into any of the railway trucks in waiting, by raising the grating $c^1$, as shown in dotted lines. The agitation the coke receives from the bar screen, does not only dispose of the breeze, but it loosens the coke lightly,

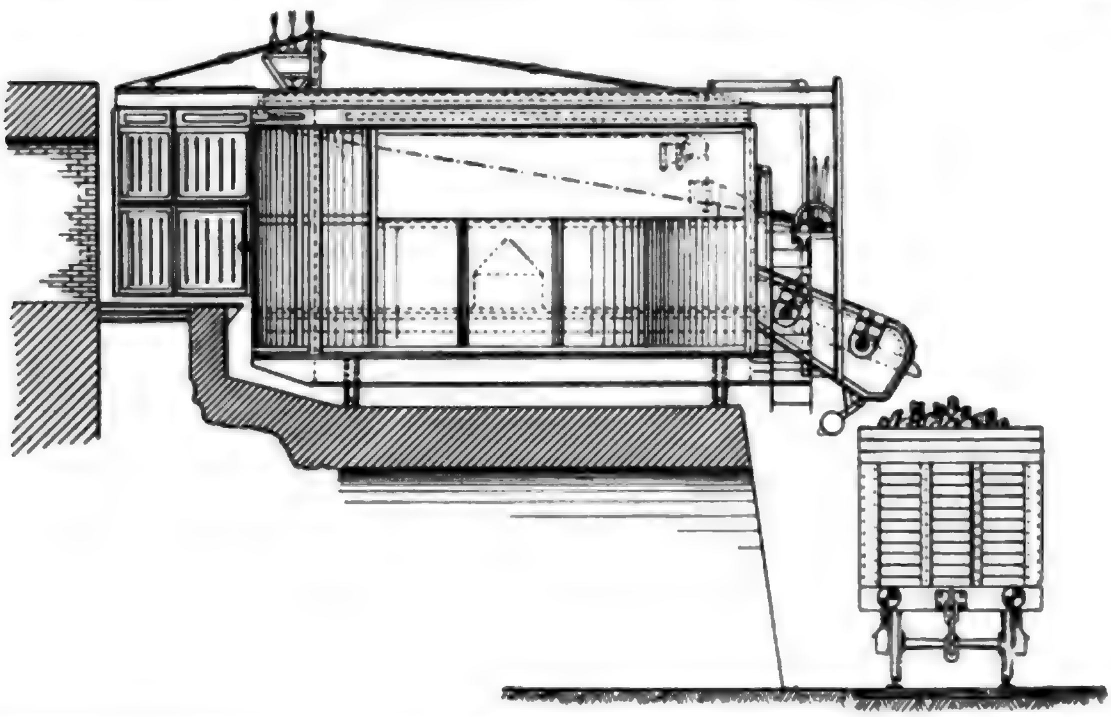


FIG. 32.—ELEVATION AND CROSS SECTION OF THE GOODALL MACHINE AS MANUFACTURED BY W. J. JENKINS AND CO., LTD., OF RETFORD.

and with a minimum of breakage, for the easier access of the quenching water to all parts, and a more uniform cooling. The screenings are delivered at intervals to a classifying plant at the end of the battery. The whole machine can be worked by one man, and is operated by a 35 h.p. motor, a 6 h.p. motor driving the pump.

The latest machine which automatically receives, quenches, screens and delivers the whole charge of an oven into any available truck along the whole line of coke ovens, is that of Goodall, and it is at work at the Weardale Steel, Coal and Coke Co., Spennymoor, as well as at several other large establishments. Figs. 32 & 33. The machine consists of a large iron frame running on eight wheels, on rails placed in the position usually occupied by the bench or quenching floor. The machine is fitted with motor and gearing to propel it along the rails in either direction and to revolve the table or coke receptacle, and drive the shaking screen. In the centre of the frame there is a substantial cast steel footstep bearing, which receives a short vertical spindle. From this axle, leading to the perifery, horizontal girders are fixed which are connected at their extremity by a cast steel ring having teeth at its lower edge and forming a large wheel which gears into a pinion on a horizontal shaft. Below this turn-table there is a rail bent into a ring-form, which gives the table support and stability, by means of a ring of rollers running on the same. The framework of the table so formed is covered with interchangeable, perforated cast iron plates, so as to form a revolving table 20ft. diameter to receive a charge of coke; the table is surrounded by plates, which are also lined again with interchangeable cast iron plates up to the height of 3 ft. There is a slot like opening, with guide plates, in this outer cylindric ring on the oven side of the machine, sufficiently large to allow the cake of coke to enter. Directly opposite this opening is a large floor in the same cylindrical casing, manipulated by a winch and chains in such a way that when the door is closed the inside of the casing is a complete ring, but when open the door projects inwards and reaches to the centre of the turn table, and being fitted with plough-shaped castings on the back, acts as a scraper to remove the coke from the revolving table. Under the doorway is arranged either a fixed or jigging screen, and the coke coming from the table falls on to the screen and passes thence, properly screened, into the railway wagon. A receptacle below the screen receives the breeze and small, which is emptied periodically. Above the revolving table, as well as down the sides of the cylindrical casing, is a net of water pipes, perforated so as to act as sprays for quenching the incandescent coke, and a small hose for spraying water by hand is also provided, to play in any direction where it may be necessary.

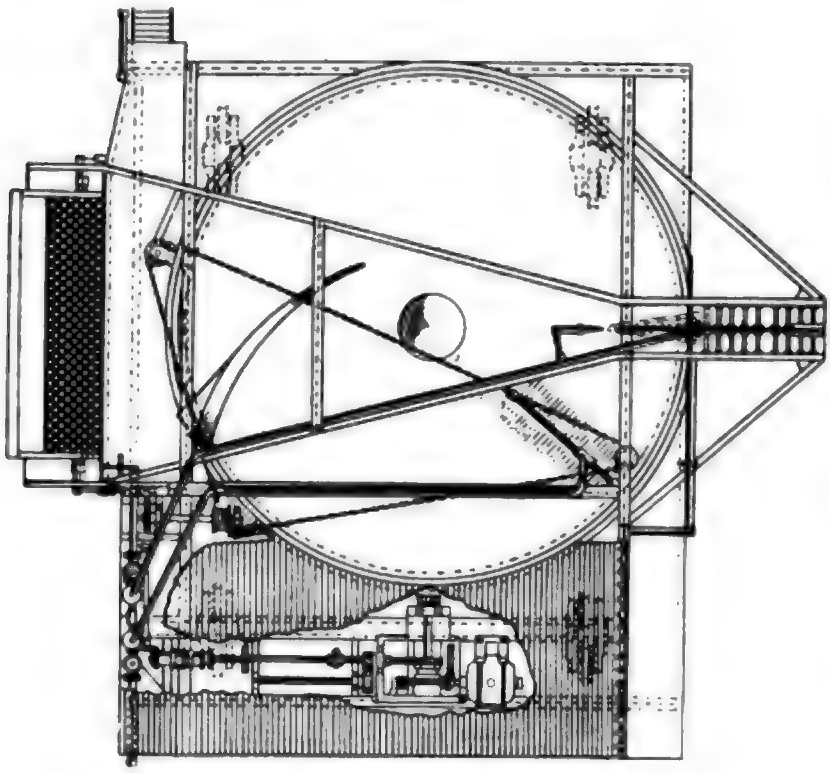


FIG. 33.—PLAN OF GOODALL MACHINE SHOWN IN FIG. 32.

FIG. 34.—THE GOODALL MACHINE SHOWING THE COKE BEING SCREENED AND LOADED INTO WAGGONS.

The method of working the machine is as follows :—First the huge apparatus is driven along the rails and placed opposite the oven to be discharged ; the oven door and the receiving slot having first been opened, the pushing then commences. As soon as the red-hot cake of coke enters the machine the water is turned on and the quenching begins. When the coke has reached about one-third across the table, the latter is caused to revolve in the direction of the clock. The coke then rests on the table, and the continued motion of the latter, combined with the continuous forward motion of the cake of coke, gently promotes the distribution of the contents of the oven over the revolving table. The quenching operation proceeding all the while by water being sprayed on to the coke both from above and sideways, until at last all the coke is on the table, which is now stopped and the machine moved a few feet out of the way so that the oven door may be put on at once. The water is now shut off and a reasonable time allowed for steaming and drying, say 10 minutes, after which the table with its load of coke is slowly revolved, and the attendant with his hand hose sprays water on any red places until the whole of the coke is quenched. Surplus water drains away immediately through the perforated plates in the table, and so avoids over-wetting of the bottom coke. The small breeze which passes through with the quenching water collects in large bins between the rail track, divided off transversely by walls ; here the breeze settles at the bottom and the water percolates through to a drain, so that the remaining breeze may be collected from time to time.

The quenching being completed after about 10 minutes, the flexible water connection between the fixed main and the machine is disconnected, and the same is propelled along the rails to any waiting wagon, either in front of, or some way beyond, the oven from which the coke came. The discharging door is then opened a little way at first, inwards, and the table revolved in a counter-clo kwise direction; the coke is, in consequence, gradually pushed out by the plough-like door, on to the screen, which is set in motion by means of gear from the motor, and the screened coke is automatically loaded into the wagon. (See Fig. 34).

One of the important features of the system is the expeditious way in which the coke is handled, the time occupied from the start of the push to the time when the door is on the oven again ready for re-charge, is only 8 minutes, and the whole operation from the beginning of the loading into the wagon, including the steaming or drying period, does not require more than 27 minutes.

The principal advantages of this machine are the great simplicity, in spite of its automaticity (the weight being only about 28 tons), and the fact that the hot coke comes only in contact with renewable cast-iron plates, a material which is least effected by its contact.

The installation at the Weardale Steel, Coal and Coke Co., at Spennymoor, has been at work for nearly two years ; it serves a battery of 60 ovens, with a yield of 1,700 tons per week, and is attended by two or three men only, as against 21 to 27 when the coke was quenched and loaded from an ordinary hearth by hand. In addition to this advantage, the breakage of coke is less by ½ per cent., and the moisture contained is below 2 per cent.

The machine is driven by a three-phase electric current from the central station close to the works, but it is of course equally adaptable for steam-power.

# THE NEW DOCK DEVELOPMENTS AT LIVERPOOL

**By John B. C. Kershaw**

THE combined loading and graving dock which is to be opened at Seaforth, Liverpool, by their Majesties the King and Queen on the 11th of this month, represents the completion of the first stage of a scheme of dock development, that was adopted by the Mersey Docks and Harbour Board eight years ago, and for which Parliamentary Powers were sought and obtained so long ago as 1906. The necessity for this development of the existing dock accommodation at Liverpool is due to the continuous growth in the size of Ocean liners, a growth which is well-illustrated by the following table, showing the length and tonnage of the more important boats built for the Liverpool and New York service during the past thirty years.

TABLE I.

| Year. | Ship. | Line. | Length in feet. | Registered Tonnage. |
|---|---|---|---|---|
| 1881. | "Servia" | Cunard | 530 | 7,392 |
| 1888. | "New York" | American | 560 | 10,798 |
| 1893. | "Campania" | Cunard | 622 | 12,500 |
| 1899. | "Oceanic" | White Star | 685 | 17,273 |
| 1901. | "Celtic" | White Star | 689 | 20,904 |
| 1903. | "Kaiser Wilhelm" | North German Lloyd | 700 | 20,000 |
| 1903. | "Cedric" | White Star | 689 | 21,035 |
| 1904. | "Baltic" | White Star | 709 | 23,786 |
| 1906. | "Adriatic" | White Star | 709 | 24,540 |
| 1907. | "Lusitania" and "Mauretania" | Cunard | 790 | 32,500 |
| 1910. | "Olympic" | White Star | 883 | 45,324 |
| 1913. | "Imperator" | Hamburg American | 880 | 50,000 |
| 1913. | "Aquitania" | Cunard | 901 | 50,000 |
| 1913. | "Vaterland" | Hamburg American | — | 50,000 |

Compiled from "Engineering."

It is curious to note how quickly the largest and swiftest boat of any one year is superseded and becomes out-of-date. The *Servia*, the *Campania*, the *Oceanic*, the *Celtic*, the *Kaiser Wilhelm*, and the *Adriatic*, each in turn within the period covered by this table, have been the crack boat of the Atlantic—and although the *Lusitania* and *Mauretania* have retained this position for a longer period than usual, they lost their supremacy as regards size in 1910, and now only retain their position on the ground of their speed. The growth in length and speed of the Atlantic liners since 1881 is, however, overshadowed by the enormous increase in their tonnage; the 12,500 tons of the *Campania* (which was considered a huge boat when she was built in 1893) being only one-fourth that of the three ships now nearing completion for the Cunard and Hamburg Companies. In view of the fact that boats of 900 feet in length and of 50,000 tons displacements were already planned, the original scheme of the Mersey Docks and Harbour Board, to which reference has been made above, provided for the construction of a new half-tide dock, and of two berthing and loading docks at the north end of the Dock Estate, at a total estimated cost of £3,250,000 (see Fig. 1). These docks were to be named the Gladstone Docks in recognition of the great services rendered to the commerce of Liverpool by Sir Robert Gladstone, a former Chairman of the Mersey Docks and Harbour Board, and not as the general public imagined as a tribute to the great politician of the same name, who was born in the City of Liverpool, earlier in the nineteenth century.

Owing to various causes upon which it is unnecessary to touch here, the development of this original scheme of dock extensions was delayed, and is

only now being taken in hand. In order, however, to be ready for the new 900 feet boats when they arrived in the Mersey, the directors of the Mersey Docks and Harbour Board decided in 1910 to add to the original scheme by constructing a combined loading and graving dock at Seaforth, capable of receiving and docking for repairs, the largest liners yet planned or contemplated. Fig. 2 shows the plan of this new dock in relation to the existing dock estate and the surrounding property. The site chosen for the new dock was outside the enclosing wall of the existing dock estate, upon a portion of the sandy foreshore over which the Dock Board had purchased all rights some years previously. A more unpromising looking piece of land for dock construction it would have been difficult to find, as the tides covered it twice every twenty-four hours, and much of the shore at this point consisted of quicksands and muddy channels. Trial borings had been made, however, early in 1910, and the engineers of the Dock Board had proved that from 20 to 30 feet below the sand there existed a substratum of red sand-stone rock, which would serve as a sound foundation for the retaining walls and bottom of the new dock. No excavation work was possible, however, until the area of foreshore required for the dock had been enclosed and the sea had been excluded from the scene of engineering operations. In September, 1910, therefore, 1,000 navvies commenced to build a clay embankment round the site, the clay being obtained from the excavations for the other two half-tide docks, within the existing dock wall. (See Fig. 1.) Rapid progress was made with this preliminary work, and early in January, 1911, the gap between the two ends of the embankment was closed on an ebb tide, and the work of excavating for the dock walls was commenced. Fig. 3 shows the general appearance of the enclosed area, about this date, while

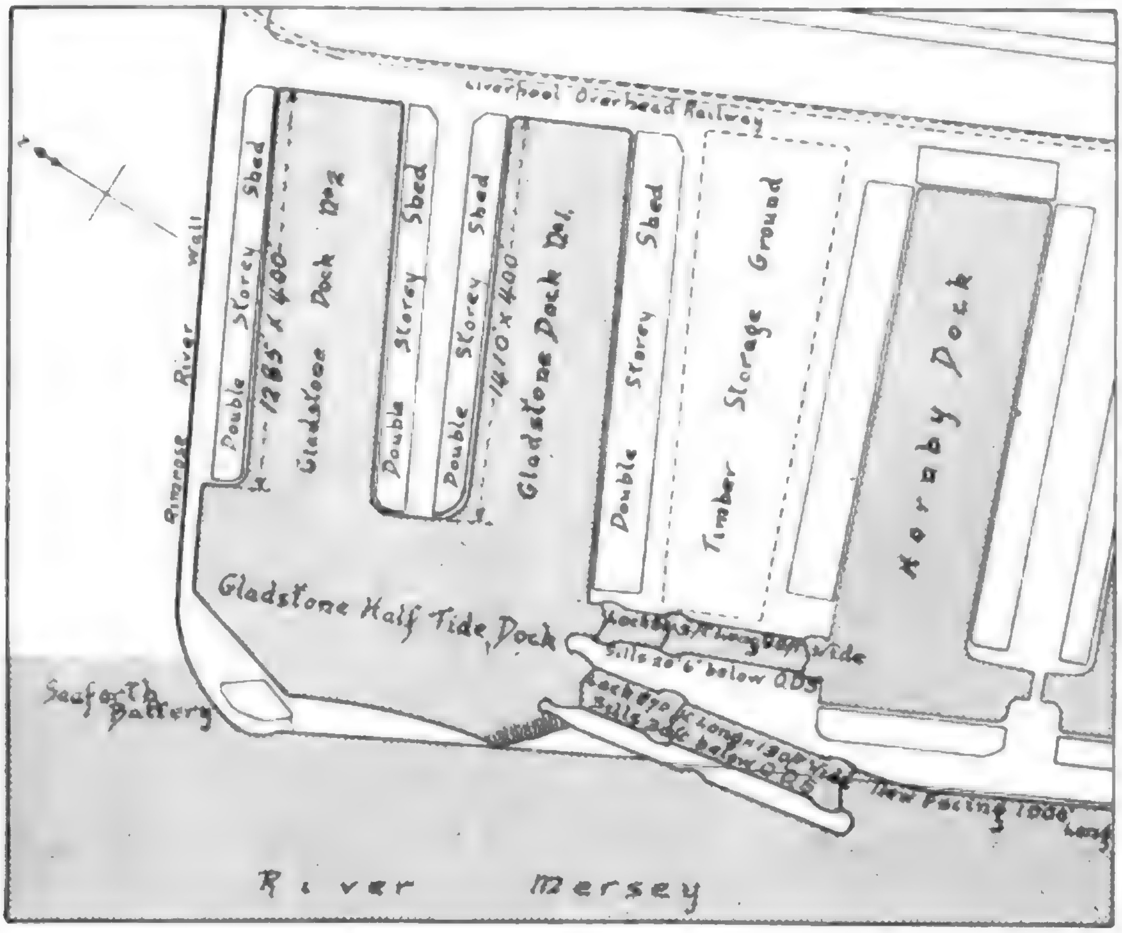



FIG. 1.—PLAN OF ORIGINAL SCHEME OF DOCK EXTENSION AT LIVERPOOL.

Fig. 4 is a photograph taken at a later date in one of the trenches, and shows the dimensions and style of the timbering employed. These trenches were 30 feet wide and over 50 deep, and although it was expected that some trouble might be caused by the percolation of water through the surface sand, little pumping was required, and the red sandstone was met with underneath the boulder clay, at depths varying from 30 to 45 feet below the surface. The work of filling in the foundations for the retaining walls was then commenced at the eastern end of the dock. Some idea of the magnitude of the work may be gathered from the fact that 700 to 800 men were employed regularly at this period of the construction, working on day and night shifts, and that 400 tons of cement was being employed per week, for the concrete foundations of the dock walls.

A total of 25,000 tons of cement has been used for the whole work, upon which between 800 to 1,000 men have been regularly employed since September, 1910. The work of dredging out the bed of the Mersey opposite the entrance of the dock was also commenced about this date, and the following figures show the amount of material removed from the river and entrance channel, and from the site of the new dock, in the course of the past 2½ years :—

GLADSTONE DOCK EXCAVATIONS.

| | | Cubic Yards. |
|---|---|---|
| Soft soil in trenches | .. | 120,018 |
| Rock in trenches .. | .. | 30,760 |
| Soft soil from dock.. | .. | 165,081 |
| Rock from dock .. | .. | 63,826 |
| Total .. | .. | 379,685 |

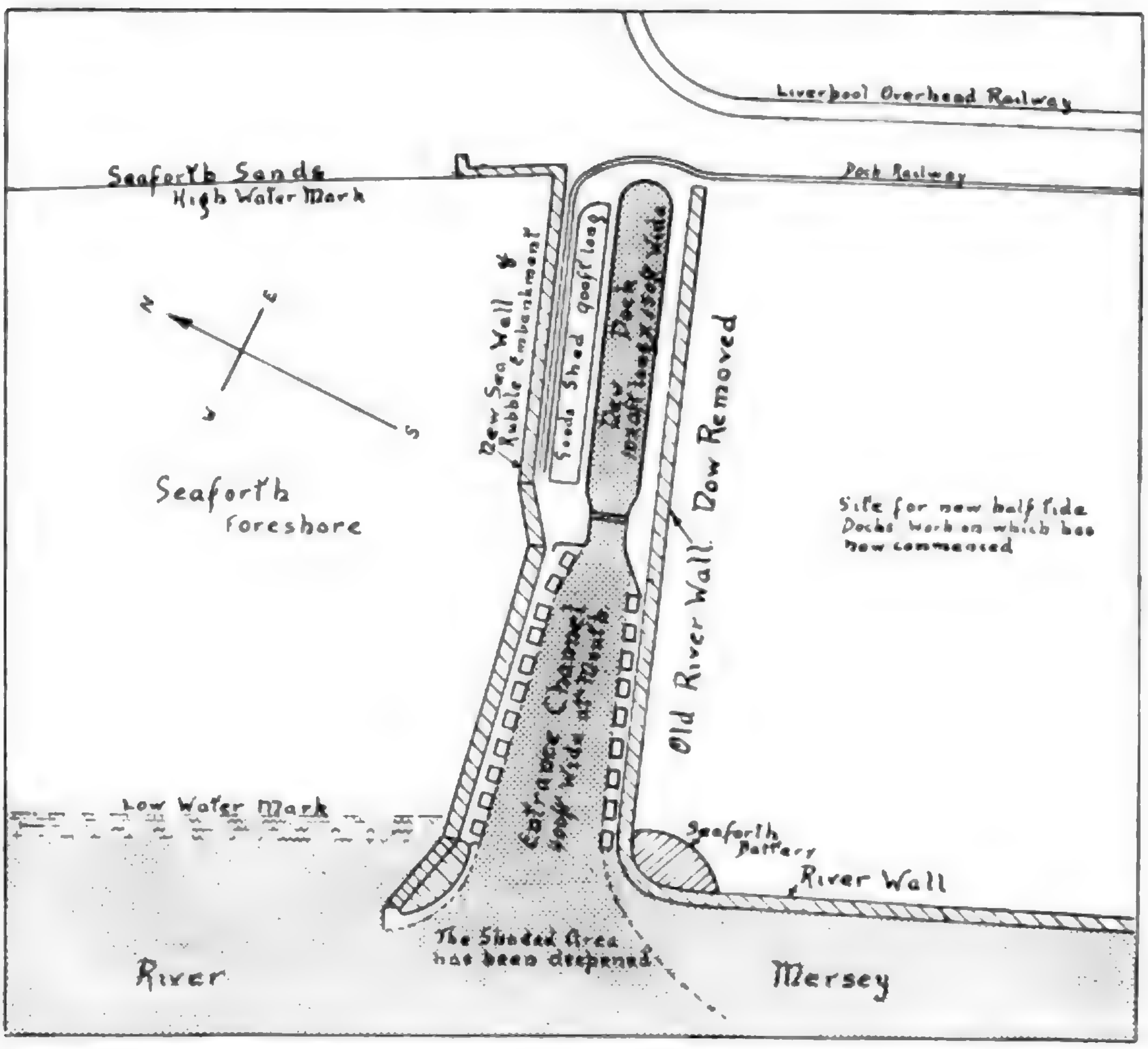



FIG. 2.—PLAN OF NEW GLADSTONE LOADING AND GRAVING DOCK.

ENTRANCE CHANNEL DREDGING OPERATIONS.

| | Cubic Yards. |
|---|---|
| Material removed by Dock Board Dredgers from river bed and entrance channel .. .. .. | 1,105,000 |

The removal of one and a half million cubic yards of sand and rock within the period named would have been impossible 25 years ago—the modern steam excavators and dredgers are the powerful auxiliaries that have rendered such a feat possible.

The chief engineering features of the new dock are that it is a combined loading and graving dock; that its entrance is to be closed by a sliding caisson and not by dock-gates; and that ships entering the dock will do so directly from the River Mersey, through a bell-shaped entrance channel 400 feet wide at its mouth, narrowing down to 120 feet at the dock (see Fig. 2) The Mersey bed has been dredged to give a mean depth of 27 feet below the old dock sill in this entrance channel, the sill of the dock itself being two feet higher; and thus with a 20 foot tide there will be a depth of 47 feet of water in the channel, and of 45 feet on the dock sill.

The dock itself is 1,020 feet in length, and 155 wide on the waterline and, as already stated, a special feature of the construction is that it can be used as a graving dock, pumping machinery having been provided for emptying the dock in a few hours, when necessary, for examination or repair purposes.

This feature of dock construction is not new at Liverpool, the old Huskisson Dock having been constructed and used in this way over 50 years ago. The combined type of dock had not proved very popular, however, and the old Huskisson Dock was the only one of this type constructed for many years. The adoption of this design for what

FIG. 3.—SITE OF NEW DOCK AFTER ENCLOSURE. GENERAL VIEW OF THE CLAY AND RUBBLE EMBANKMENT TAKEN IN JAN., 1911

FIG. 4.—ONE OF THE TRENCHES FOR THE DOCK WALL.

FIG. 5.—VIEW OF DOCK FROM RIVER END IN MARCH, 1913. THE CAISSON CHAMBERS IS SEEN ON THE RIGHT OF THE ENTRANCE.

undoubtedly is the largest graving dock in the world, and the only one that can accommodate the huge ocean liners now approaching completion on the Clyde and in Germany, is, therefore, a sign of some importance in its bearing upon the dock developments of the future.

The sliding caisson which is to close the dock entrance is another feature of the construction of special interest to engineers, for although this method of closing docks has been used extensively abroad, and by the British Admiralty, it has not been employed at all generally for ordinary commercial docks in this country. Dock gates would, however, have been unmanageable and unsafe for closing a dock entrance 120 feet wide, or for holding up 7,000,000 cubic feet (200,000 tons of water) apart altogether from the difficulty of providing the necessary space for them in the funnel-shaped entrance channel. The caisson form of

FIG. 6.—VIEW OF THE CAISSON IN COURSE OF ERECTION. THE CAISSON MEASURES 133 FT. IN LENGTH × 50 FT. DEPTH × 25 WIDTH AND WEIGHS 1,200 TONS.

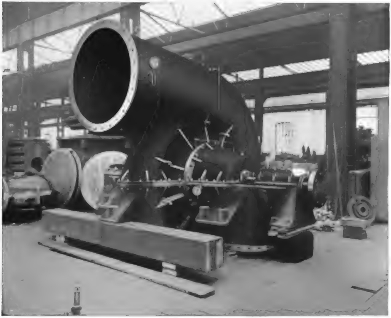


FIG. 7.—ONE OF THE WORTHINGTON 54" HORIZONTAL CENTRIFUGAL DOCK PUMPS UNDER CONSTRUCTION.

closing was therefore the only one practicable under the circumstances. Fig. 5 is a view of the dock taken from the clay embankment, on the river side, in March of the present year, and shows the caisson recesses at each side of the entrance. The caisson chamber is on the right hand side of the dock in this Fig., and is a large chamber measuring 130 by 60 by 30 feet, faced with stone. The caisson itself is constructed of steel girders and plates on the plan of a pontoon, its dimensions being 120 feet by 50 feet in height by 25 feet in width; its weight is 1200 tons. Fig. 6 is a view taken of the caisson chamber when the caisson was half c mpleted. Since it is almost balanced in the water by the enclosed air, the power required to move it in and out of the caisson-chamber on the right hand side of the dock, will be chiefly employed in overcoming the resistance of the water. Two 150 h.p. electrically-driven motors are provided for this purpose, and the power is transmitted to the caisson by wire cables, working in sheaves attached to the opposite wall of the dock entrance. The caisson has been built by the Motherwell Bridge Co., of Glasgow, and the iron work was first prepared at their Works and after erection there transhipped to Liverpool. The caisson is divided into three compartments by transverse plating, the middle compartment being the air-chamber which gives it the required buoyancy. It is also provided with greenheart timber runners, which slide on polished granite footsteps in the dock sill. These will be lubricated with oil supplied under pressure by a small pump when the caisson is in motion.

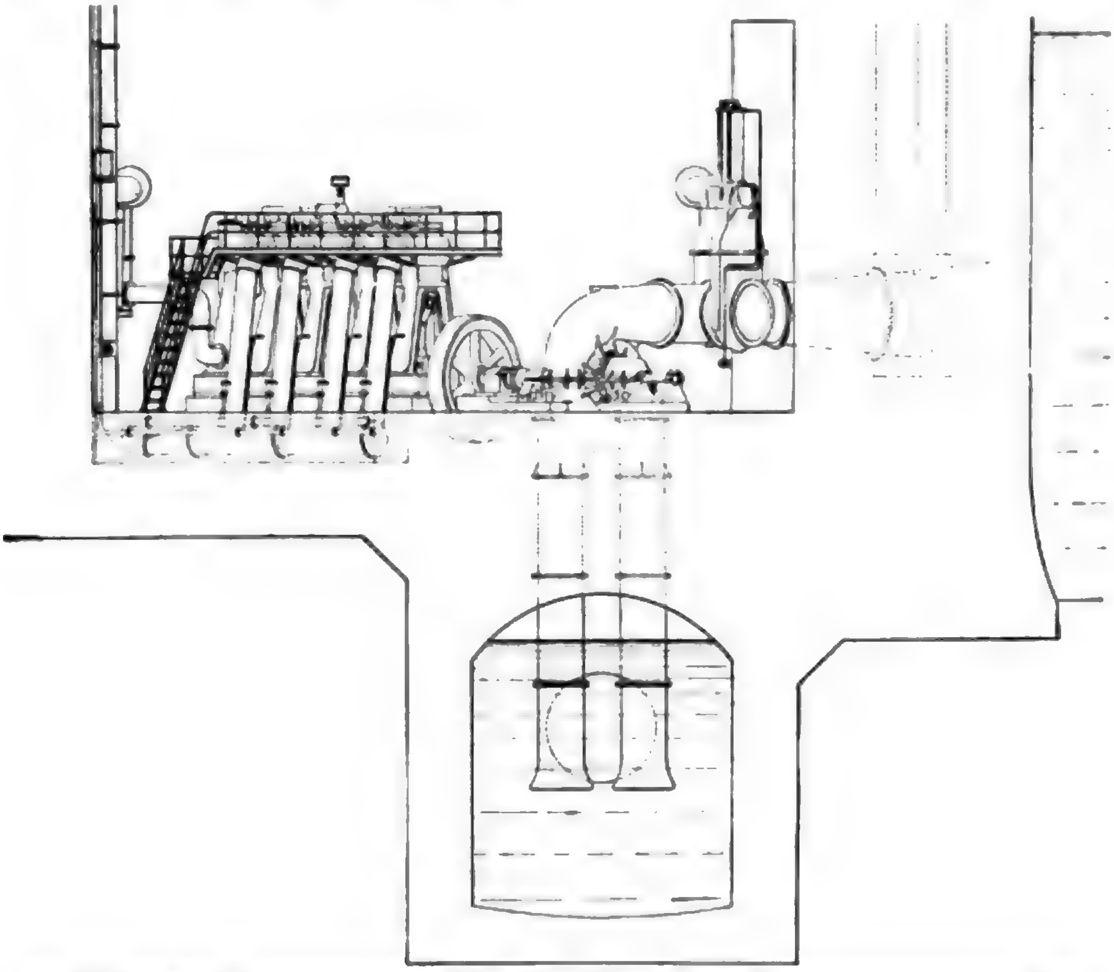


FIG. 8.—CROSS SECTIONAL ELEVATION OF PUMP ROOM SHOWING WORTHINGTON PUMP DRIVEN BY THE DIESEL ENGINE.

The pumping plant which is to be utilized for emptying the dock when it is required for ship repairing purposes, is contained in a large chamber located next to the caisson chamber, on the south side of the entrance channel of the dock.

FIG. 9.—DOCK COMPLETED AND FILLED WITH WATER.

Since it will be necessary to empty the dock entirely in 2½ hours the pumping plant is of considerable size and capacity, and comprises 5 units of 1,000 h.p. each. The pumps are of the centrifugal type, and have been constructed by the Worthington Pump Co., they are provided with discharge pipes 54 in. in diameter. Fig. 7 is a photograph of one of these pumps under construction, taken at the maker's works. Each pump is to be direct driven by a vertical four-cylinder two-cycle Diesel oil engine, running under normal conditions at 180 rev. per minute. (Fig. 8.) The engines are being built by Messrs. Carels Freres, of Ghent, and are the only portion of the dock plant which is of foreign make. Whether it was wise for the engineers of the Mersey Docks and Harbour Board to adopt oil-engines for this large and important pumping plant, when electric power was available, time alone will reveal.

On the north side of the dock, a single-storey shed 900 feet long and 100 feet wide has been erected, and four 30 cwt. cranes, of the moveable type, have also been provided. On the south side of the dock two similar cranes, one of 40 tons and one of 5 tons load capacity, will be installed. Fig. 9 is a photograph of the dock taken after the water had been admitted early in June.

The total cost of the dock has been slightly under the estimate of £500,000, and the works have been carried out entirely under the direction of the Dock Board officials, who are to be congratulated on the success of their efforts to have the dock finished by the date originally planned.

In closing this article, some details may be given of the larger scheme of dock construction at Liverpool, which is now being taken in hand, at an estimated cost of over £3,000,000. The plans for this scheme are shown in Fig. 1, and include the construction of a half-tide dock of an area of 14¾ acres, with an entrance from the river by a lock 870 feet in length by 130 feet wide, and the construction of two branch docks each 400 feet wide, with lengths of quay accommodation,

varying from 1,270 feet up to 1,570 feet. The area covered by these branch docks will be 13 acres and 12½ acres respectively, thus giving a water area of 40 acres for the whole scheme. Double storey sheds will be erected round these two docks, which when completed will be able to berth four of the largest liners yet constructed, at one and the same time. The Dock Board at Liverpool is, therefore, providing ample facilities for berthing and docking the 50,000 ton boats of the present shipbuilding era.

Should the progress in shipbuilding construction that has characterised the last quarter of a century be continued through the next 25 years, the problem of berthing and docking facilities, however, will again become urgent, and once again those who control the Harbours and Docks of our great ports will have to deepen their river-beds and quays, and increase the size and area of their docks, in order to provide the necessary berthing and loading accommodation for the still more gigantic liners of the year 1940.

In the writer's opinion, however, the increase in size and tonnage revealed by Table I. is not likely to continue unchecked for another decade. It will soon be found that the increased dock accommodation entails large capital outlay, the interest upon which will have to be met by increased dock and harbour dues; and steamship owners will gradually realise, if they have not already made the discovery, that except as advertising media, these leviathan ships cannot earn a fair return upon the capital invested in them.

The moderately-sized passenger and cargo boat and the tramp-steamer, that can go anywhere and dock in any port, will still provide the larger share of the profits of our ocean-carrying trade; and the shipbuilding progress of the next quarter of a century will probably be directed to the development of the speed and efficiency of this class of boat, rather than to the design and construction of more 50,000 tonners.

Our thanks are due to the courteous officials of the Liverpool Docks and Harbour Board for many of the facts and figures given in this article, and also for the loan of two of the photographs which illustrate it.

# TECHNICAL EDUCATION

## "TO PARENTS AND GUARDIANS"

By W. D. Wansbrough

IT may fairly be presumed that the reader is, or has been, or will some day be, very intimately concerned with the problem I propose to discuss—the problem of the mental outfit of the boy who is approaching the end of his school career; whose future is to be made or marred by the decision which has to be faced within the next few months—What shall we do with our boy?

The "other professions in which men engage, the Army, the Navy, the Church or the Stage," we may put aside at once—our boy is to become an engineer. That has been decided years ago. His marked aptitude for mechanical pursuits has long since convinced his parents that there is nothing else for it, and the only question is how he shall best be prepared for entering upon his destined path in life.

Shall his final year at school be so directed as to familiarise him with mechanical drawing and the practice of mechanical engineering construction? The means of doing this are now to be found in all public schools, and in most private educational establishments of any standing.

At first sight this would seem to be a foregone conclusion in the affirmative. The well-ordered laboratories and workshops in which so many hours per day or per week are to be spent; the impressive array of instruments and appliances, the beautifully kept machine tools, the rows of benches where "all is right and nothing wrong"—all these offer convincing testimony to the advantages of the "engineering course." "Certainly! certainly!" says the inspecting parent—"as much time as possible here, please"—to the huge delight of the pupil, who has for years longed for such a chance of exercising his constructive abilities. But is it the best thing for the boy?

I am going to advance the paradoxical assertion that it is an excellent thing for the boy, who is *not* going to adopt engineering as a profession, that he should spend a certain part of his time before leaving school in acquiring a working knowledge of the tools and machines employed in mechanical engineering, and of the processes of the forge and the foundry. In after life, wherever his lot may be cast, he need never be a helpless looker-on, while some other man with not half his ability, takes the lead in cases of accident or emergency.

But in our case there are other considerations which in my view indicate a different trend in the curriculum of the final year at school. Of engineering education, pure and simple, he will have enough and to spare in succeeding years, and it is a sheer waste of valuable time to anticipate this by any preparatory course at school.

Those in authority in the electrical or engineering works presently to receive the boy whose future we propose to follow, are rather apt to regard with polite indifference the fruits of the "workshop course" in which he has achieved some measure of distinction, and the boy himself, when set to work, views with pained surprise, the limited scope allotted to his energies. It appears an absurd and sinful waste that he, who has taken the principal part (say) in the construction of a small steam engine, should be expected

to confine himself strictly to the elementary operations of nut-facing or bolt-turning. In short, he has to begin at the beginning in any case, and it is not long before he discovers the essential difference between school and apprenticeship or pupilage, which is, that in the one case he is taught, and in the other he is given the opportunity of learning for himself.

Better far, surely, to make the utmost use of the precious final year at school in the rounding off and completion of a liberal education. We have to bear in mind that what we hope to make of our boy is ultimately an organiser—an administrator, not a workman—and the foundations of success in this capacity are laid to a very large extent during the last few terms at school. A boy who acquits himself well in the comparatively responsible positions he is called upon, or elected, to occupy (whether in the school work or at sports or games) is qualifying himself for more serious work later on. Sir Andrew Noble, the chairman of the great firm of Armstrong-Whitworth, employing 30,000 hands, said some time ago: "Speaking as an employer of labour, I should say that a pleasant speech and manner, tact in dealing with others, and some power of organisation are of the utmost value; and it is precisely those qualities that a boy acquires, or ought to acquire, in his later years at a public school. A stricter discipline, a wiser supervision, more authoritative yet sympathetic advice as to conduct, are more possible at school than can ever be the case in after life; and a more constant and generous association with his equals rubs off angularities and leads to amenity of disposition. Without such qualities even the highest scientific attainments will never make a captain of industry, and in selecting candidates for appointments the man of business distinctly prefers a youth who has the benefit of some years at a good school. . . . I am not in accord with those who think that modern languages should supersede the classics as a means of education." This last sentence records the deliberate conviction of a man whose position and attainments entitled him to speak with authority; and I quote them here, though not quite relevant to our present argument, as a useful hint upon a much-discussed question just now. Sir Andrew does not, of course, underrate the importance of a knowledge of modern languages, but he, very rightly, holds that a classical education impresses upon its recipient a certain stamp, or hall mark, of no secondary value, in his intercourse with the world.

Therefore, in any discussion as to the age at which a boy should leave school, the great incidental advantages that he gains from a reasonable prolongation of his school days should not be lost sight of. Somewhere between the ages of seventeen and eighteen he should show unmistakeable indications that he is fit for making his start upon his chosen career.

There are, of course, exceptional cases where, for two opposite reasons, it may be desirable to withdraw a boy at an earlier age. It may be that he is "doing no good at school," in which case, if it be that he does not "get on" with his masters, or with his fellows, the sooner he leaves and adopts some profession—other than engineering—the better. Or he may be a bright and clever lad whose one idea is to get to work, and to whom the prospect of another year or two of school is positively distasteful. It is impossible to prescribe for individual cases, but the voice of Nature cannot be ignored, and it becomes the duty of the person responsible for the boy's welfare to give every consideration to his desire after making him acquainted with the arguments for and against such a course.

Now comes the all-important question. To whose care shall our boy be entrusted? A much more difficult problem this, than the choice of a school; though it is a fact that at this turning point in the boy's life his future career is very often determined by the most accidental circumstance. The large engineering and electrical firms, or companies, do not advertise or make known that they are prepared to take pupils; and the parent, having nothing to do with engineering himself,

and being saddled with a son whose one idea of a profession lies in that direction, is at a loss where to turn until he hears that someone he knows has a friend who is connected with a firm of engineers. To this firm, therefore, he goes, with an introductory letter, and the matter is settled in no time. (The same man, if he had a few hundreds to invest, would make the most careful inquiries as to the position and prospects of the concern before venturing his money in it.)

Again, some particular firm or company may be indicated, through influence, as the one place for the boy to go to—as, where the parent is "interested" in the concern. This is another case where the arguments in its favour appear unassailable. Take the extreme example where the boy's natural guardian is himself a principal or partner in the firm in question. It is at least open to question whether it is to the boy's own real interest that he should be "put through the works," it being practically certain that whatever his conduct or ability may be, he will ultimately be found a place in its direction; whilst it is nothing less than a certainty that the firm would be a gainer by his accession a few years later bringing with him fresh experiences acquired under different conditions.

The ideal training for a boy who is intended for the profession of mechanical or electrical engineering—and I cannot too strongly urge the combination of these two branches—would be such a combination of theoretical and practical experience as would be afforded by the union, if such a thing were possible, of a technical university with an engineering manufactory. And in this impossible institution the learner would have his theoretical and his practical training in alternate spells.

He would not be "making things" in a workshop without some knowledge of their use and fitness; nor would he be attending lectures, and acquiring facility in the mathematics of electrical and mechanical engineering, lacking meanwhile that intimate acquaintance with structure and form in the concrete, and with the current methods of manufacture, which can only be acquired by taking part in the actual processes of the workshop, the forge and the foundry.

Failing this ideal programme what are the alternatives? The good old system of apprenticeship, the natural means of passing along from one generation to another what may be described as craftsmanship, is out of the question in our case. In the first place it is incompatible with the prolonged period of school education, which we are agreed is a necessary equipment for the boy who is being trained to take an officer's part in the great industrial army. Either by purchase or by favour our boy has to be shown as it were behind the scenes. He has to be given the opportunity of learning the whole intricate working of a modern manufactory, and the co-ordination of its numerous separate departments involving many different trades. When this aspect of the question is once grasped, one ceases to wonder at the heavy premiums asked by great and prosperous firms as the price of entry to their works and offices. Speaking from actual experience I should be inclined to say that a decent well-behaved boy, the son of a workman, apprenticed without a premium and taught a single trade, is a better bargain on the whole for his employers than the average pupil paying two or three hundred pounds for his initiation. There are, of course, brilliant exceptions, but on the other hand there are probably as many cases where boys, starting under the most unfavourable conditions, but having the right stuff in them, have by sheer merit forced their way to the top, and made themselves a power in the works, picking up their theoretical knowledge at a technical school or by private study.

Take another alternative. You may enter your son at one of the Universities having a Faculty of Engineering—the cost is much about the same—where he will have the privilege of attending lectures upon every engineering and electrical subject, by men whose names are almost household words in engineering circles. In admirably equipped

workshops he will, at stated hours, take his turn at lathe or machine tool, alternating this by experiences in the use of hammer, chisel and file. In some cases there is also practice in pattern-making, moulding and smithing. In each of these departments there is an expert instructor, to whom all can apply for advice or help. It would seem that this course embodies every possible advantage. The scientific teaching is undoubtedly of the best, and it is the student's own fault, if by inattention, or non-attendance, at the lectures he fails to assimilate the mental pabulum poured forth. So in the workshops ; there is no compulsion, though there is every encouragement to take a piece of work in hand, and ultimately to complete it. There is a sense of spaciousness in the buildings, and an air of learned leisure about the occupants, which is very comforting to the aspirant for academical honours in the Faculty of Engineering.

Again we have to ask ourselves—Is this the best thing for the boy ?

To enable us to form an opinion upon this point let us examine briefly the alternative system which we may distinguish as the works training. In comparing this with the University training, the first and fundamental difference which strikes us is in the purpose for which the two institutions were built and equipped—the one for the formation from the appropriate material of engineers and electricians ; the other, in precisely the same manner, for the output of finished machinery from metals or materials in their crude form. The presence of pupils would have but little effect upon this output. There is a relentless driving force in operation—the pressure, in fact, resulting from commercial competition—which requires that the place shall be effectively manned, and that every tool and machine shall work up to its maximum, as nearly as may be.

To the unaccustomed spectator (the boy's parent for example, being personally conducted through " our works " by the latest recruit) the aspect of a great machine shop is almost bewildering. The familiar phrase, a " hive of industry " instantly offers itself as the only adequate description of the busy scene before him. As far as the eye can reach the whole ground space appears to be crowded with machinery in motion, driven from above by a maze of flying belts. There is a curious deadened roar, the summation of ten thousand separate noises, the ground appears to vibrate beneath his feet, the very building seems to be alive, and the air to be charged with electricity. This is the general effect, but it wears off immediately, as the eye becomes accustomed to the scene, and able to grasp the details. Individual workers, and the machines they handle or control on closer examination are seen to be working without haste and without delay. The peeling off of iron and steel shavings by revolving or reciprocating machine tools, which is the staple industry in this building, is apparently done quite gently and with no display of force ; but every man and every tool is dead set upon the one particular operation assigned to him or to it. It is a triumph of organisation, an example of law and order. And so throughout the many departments of an engineering factory, the apparent confusion resolves itself into its units, after the first glance, and it will be seen that a steady stream of products is flowing towards the assembling or erecting shops. It is in the expectation that our boy (who has hardly yet got over his wonder at finding himself actually enrolled) will one day be in a position to control the traffic in a place like this, that he is being put to work here. It will be seen, I think, that the practical course in the workshops attached to any teaching institution is not at all the same thing. If now we could ensure that while the boy is learning to use his hands and his brains, and reasoning out for himself the ways and methods of thought current in a great manufacturing establishment, he could at the same time be thoroughly instructed in the theory and science of his adopted profession we should have, it would seem, the ideal engineering course.

But a University having under its control a real manufacturing concern is inconceivable ; neither can the heads

of a business such as we have in mind own and direct a teaching institution on anything like the generous lines provided in modern Universities.

There is, however, an institution which has been in operation for many years past, in which the problem of this dual training has been effectively solved. I refer to the Training College for electrical and mechanical engineers known as Faraday House, in Southampton Row. This institution works in conjunction with over seventy well known engineering companies, power stations and electrical railways, who pass its pupils through a course of real practical experience in their factories and power houses.

Before proceeding further there are two observations I should like to make:

First: That the education of no present day mechanical engineer is complete, unless he is also versed in electrical engineering. Though he may have no thought of pursuing an electrical career, yet a competent knowledge of the production and distribution of electric power is almost certain to be required of him.

Second: that, as in these days we cannot be too careful in such matters, I may say that I am in no way interested in Faraday House, except as an independent observer, though I have had a good many of their pupils through my hands. Having made it clear that I have nothing to gain by advocating the Faraday House methods, we may resume by quoting from their prospectus.

The full course of training takes four years, occupied as follows:—

*First Year.*—Complete course of lectures in the principles of mechanical and electrical engineering, and the application of the theoretical knowledge so gained by practical tests in the workshops and laboratories at Faraday House; also drawing office practice.

*Second Year.*—Is passed in gaining practical experience in engine building and testing, with one of the works associated with the Institution.

*Third Year.*—The student returns to Faraday House for revision work, lectures in special branches of electrical engineering, advanced theory and technical calculations, and dynamo design.

*Fourth Year.*—Is devoted to practical electrical work in the factories or electricity works of the associated companies.

The founders of this institution recognise that it is not possible in the workshop of a training institution to give a student the practical acquaintance with workshop methods that can only be obtained in works actually manufacturing for sale; all that can be imparted is instruction in the uses of tools and machinery. Methods of management, working to time, and to price—the discipline, so to speak, of competitive manufacturing can only be obtained on the spot; thus supplementing the training given in the workshops of Faraday House by experience in manufacturing under the restrictions imposed by commercial competition. The works associated with the Institution are situated in each of the principal engineering centres, and elsewhere and cover every branch of engineering, the students are kept in touch with the parent institution by regular reports checked by the manager of the works; and by frequent visits from a member of the Faraday House staff to the affiliated works, who sees the pupils under working conditions. By this means each pupil is kept in touch, and is encouraged to do his best with the exceptional opportunities he thus obtains.

Where a pupil may not show a proper regard for time-keeping and application to work (and the times for starting and leaving work are those current in the works) it is speedily learnt by the authorities, and the position is at once explained to the parent or guardian.

Examinations for Entrance Scholarships are held once a year in April, and the Institution is able to offer appointments to all students who can be conscientiously recommended, and to assist them to better positions as time goes on. A long list of appointments now held by former pupils is given in the prospectus, also a list of the affiliated mechanical and electrical engineering firms, electrical railways, electric lighting

and power companies, and municipal electricity works.

The course was originally a two-year one, twelve months at the College, and twelve months at affiliated electrical works; it was very soon increased to three years by the insertion of twelve months at mechanical engineering work between the other two, and has now been extended to four years (at the same fees) in order to arrange for the return of the pupils to the Institution for advanced technological instruction before taking their final course of practical work.

We may now take our leave of Faraday House, which it will be seen carries out in practice the "sandwich" system of technical training generally regarded as the ideal method.

Not every parent desirous of initiating his son's career, is, however, in a position to put down the fees and provide at the same time for the boy's maintenance in London or elsewhere. With the assistance of the Technical Schools, which are now to be found even in moderate sized towns it is possible for a boy who intends to get on, to get his practical training during the day, and his science and theory in the evenings, but it cannot be too thoroughly impressed upon such that the one is of no real use, if the boy is to be anything else than a workman, without the other. This is entirely recognised both by the works authorities and by the technical schools, which, of course, exist for this very purpose, and indeed attendance at the course of technical instruction is in many cases made a condition of apprenticeship or pupilage. I may say in conclusion that nothing is more calculated to bring out the pluck and perseverance in a boy, who starts with the intention of making his own way in life, than the real hard work which is entailed by the effectual fulfilment of his obligations to both courses of instruction, when carried on simultaneously. To counterbalance the hours spent in developing his mental resources, an equally strenuous application to open-air sports and games is necessary even in the interests of health, for which there is ample opportunity all the year round, more especially during the summer months.

I do not like to close this article, which has already extended far beyond its intended limits, without a brief reference to another sort of training—the training which every boy owes to his country and which every enlightened parent should encourage by all the means in his power. I allude to the military training for which facilities are now offered by Lord Haldane's scheme, the Officers' Training Corps, of which a branch or "contingent" is in existence at every public school, and in most private ones of any standing, it being in fact at many schools compulsory to join except on production of a medical certificate. A boy enters the O.T.C. at 14. He will be provided at once with uniform, rifle and accoutrements, all of which belong solely to him, and he is expected to maintain them in a manner worthy of a soldier. A large proportion of time throughout his O.T.C. career is devoted to shooting, there being usually a miniature range on the spot with frequent opportunities for practice at a neighbouring full size range. Being passed as "efficient" he is eligible for the annual training—one of the finest holidays conceivable. (Last year, 1912, there were 4,000 cadets encamped at Aldershot, and 3,500 on Salisbury Plain for ten glorious days.)

Boys who stay at school till 17 ought to take the War Office examination for the "Certificate A" not only as a help to promotion in the O.T.C., but because it reduces by a month the probationary period in the next stage, the "Special Reserve of Officers" which is, of course, the end and object for which the O.T.C. exists. Assuming that a six months' interval between school and business training is practicable, the next step to be taken is to select a unit to join—preferably one whose regular battalion is stationed within easy distance of home. The O.C. (Officer Commanding) of the O.T.C. will then write to the Adjutant of the regiment selected, and this officer will communicate with the Colonel, who will appoint time and place for a personal interview. Assuming this to be satis-

factory, a report to head-quarters follows, with the effect that in due course the boy is requested to report himself for medical examination at the nearest recruiting office. The result of this ordeal is not communicated to the candidate, who has the long-drawn-out pleasure of perusing the *London Gazette* twice a week until such time as he joyfully encounters a paragraph reading thus :—

"SPECIAL RESERVE OF OFFICERS, 3rd Battalion, The Heathshire Regiment. John Thomas Smith, late Cadet Corporal, King Edward's School (Westhampton) Contingent, Officers' Training Corps, to be Second Lieutenant (on probation). Dated 1st January, 1913."

This anxious period of waiting may be abridged by writing or wiring (reply paid) to the War Office to ask if the Commission has been granted, if the *Gazette* notice does not appear in reasonable time, say a fortnight after the medical examination. Then begins the thrilling business of ordering the uniform. The cost of the whole outfit —service dress, full dress, blue undress and mess-kit, with boots, field glasses, uniform-case, etc., can be kept as low as £52 by going to the right tailor; and the Government grant of £40 is quite a substantial contribution towards it. The young officer will in due course be summoned to join his regiment, and his probationary period of six months will commence (being reduced by one month if holding Certificate "A," or by three months if in possession of Certificate "B.")

The obligation to serve abroad when required is understood, for the object of the Special Reserve is to supplement the regular army. A certain percentage of the first draft sent out indeed would consist of Special Reservists, who, by the way, when called up, cease to bear that title, and become part of the Army—incidentally dropping in pay thereby, as during training the officers of the S.R. of Officers receive more pay than regular officers of corresponding rank.

The intention of the War Office being that the service in the S.R. of Officers should pay for itself, the regular second lieutenant's pay of 5s. 3d.* per day is supplemented by a "messing allowance" of 4s. per day; and when under canvas for the annual training or manœuvres a "field allowance" of 2s. 6d. per day, which ought to cover all reasonable expenses.

In addition to all this, there is an obligation to serve one month with the regiment in each succeeding year, for which an annual retaining fee of £20 is paid, with pay and allowances during the month's service as above mentioned.

This annual month may possibly be a stumbling block in making arrangements for apprenticeship or pupilage, but most large employers are more disposed to encourage a lad to bear his part in his country's service than to raise objections to his absence for a month in each year, it being, of course, understood that the usual fortnight's summer holiday is taken out of it.

Finally, I should like to say that while performing his probationary training the young S.R. officer is treated with the utmost consideration by the regular officers with whom he is associated.

The experiences of this period cannot but be invaluable for many reasons. Habits of discipline are inculcated, the sense of duty becomes an abiding principle, and while the distinctions of rank and seniority are rigidly observed, the erstwhile schoolboy needs only to conduct himself as an officer and gentleman to find a very agreeable sense of comradeship in the social intercourse with his brother officers.

In the years to come the annual month of service with his regiment is eagerly looked forward to as a delightful interlude in his industrial training, and the feeling that for a brief period he is "a man under authority, having soldiers under him," will never fail to remind him of the duty he owes for the remaining eleven months to his employers and their duly appointed representatives.

* Since the above was written there has been an increase in the pay of the regular officers.

# *THE CONDUCTION OF ELECTRICITY IN METALS

By A. G. C. Gwyer, B.Sc., Ph.D.

ONE of the most characteristic, and at the same time important properties of metals as a class, as distinguished from non-metals, is their relatively high conducting power for electricity. Many liquids, non-aqueous as well as aqueous and mixtures of molten salts, and also of solid oxides, conduct electricity, but not only do they conduct much less readily than the typical metals, but also they transmit the current in a different manner. In the case of aqueous solutions, for example, the well known phenomenon of electrolytic dissociation occurs, giving rise to the formation of electrically charged molecules or atomic complexes, termed ions, and the process of conduction is effected by the motion of these electrically charged bodies, the ions, through the solution, the positive ions travelling to tho cathode and the negative to the anode respectively. In metallic conduction, on the other hand, no such transport of matter takes place, and hence it is apparent that not only is the difference between the two kinds of conduction one of degree, but also one of kind, and various theories have been brought forward from time to time to account for the observed facts.

The most recent of these theories is the so-called electron theory, and which is of such undoubted importance, that it must be referred to shortly. The theory was first propounded by certain eminent physicists, notably by Sir J. S. Thomson and others, who showed in the first place that the mechanism of conduction of electricity in metals is analogous to that of the conduction of electricity in highly rarified gases, and by the so-called Beta rays of the radio-active bodies. The latter have been proved to consist of streams of very minute negatively charged particles moving with an enormous velocity, and have been termed electrons. According to this theory, the electric current is assumed to be carried by the drifting, as it were, of the electrons in the metal against the current, or in other words the electrons move in the opposite direction to that in which the current is flowing, the atoms of the metal being supposed to be in a continual state of dissociation into electrons and positively charged residues. Since it is the electrons, and not the atoms of the metal which convey the current, the passage of the current through the metal does not imply, as Sir J. J. Thomson pointed out, the existence of any transport of these atoms through the metal, and it is well known that in metallic conduction no such phenomenon occurs, although it is the chief characteristic of electrolytic conduction. It is very striking that no other theory yet advanced offers any explanation to account for this simple and most fundamental fact of metallic conduction. Still we must not omit to say that the electron theory, in it present stage of development, is very far from being complete, and that this incompleteness may possibly be due to the fact that it has not as yet taken any cognisance of the effect of constitution upon conductivity, a factor which as we shall see is of very great importance.

*Read before the Institute of Metals (Birmingham Section).

The ability of the ordinary metals to conduct electricity varies with the metal, the ductile metals silver, copper, gold and aluminium having the highest conductivities, and the brittle metals antimony and bismuth the lowest, the conductivity of silver being no less than 75 times greater than that of bismuth. The conductivity of any material is defined as the reciprocal of its specific resistance or resistivity, and is usually expressed in Ohm-centimetres.

The conductivity of any metal is very greatly affected by the presence of even the smallest traces of impurities, and also but to a less degree by its physical condition, whether hard or soft, the soft or annealed state always having, under normal conditions, the higher conductivity. This difference in conductivity between the hard and the soft states may amount to only 2 or 3 per cent., as in the case of copper, or as much as 15 to 20 per cent., as in the case of tungsten or molybdenum. The reason for this variation is most probably to be looked for in the difference of size of the crystalline grains in the two states. In a hardened or worked metal, the crystal grains are not only smaller and more numerous than in an annealed metal, but also the contact between the individual grains is less intimate, owing to the presence in the inter-crystalline boundaries of a hard and amorphous modification of the parent substance. The recent work of Beilby, of Rosenhain, and of Bengough, upon this amorphous material. is very suggestive in this connection, Temperature, as is well known, has a most potent influence upon conductivity. Rising temperature causes the conductivity of the good conductors to decrease, that of the bad conductors or insulators to increase, and it is probable that every element has an inversion temperature, which is high for non-metals and very low for metals. The recent researches of Kammerlingh Onnes have proved that the resistance of gold wire practically disappears at the very low temperature at which the rare gas Helium boils, when liquefied, and it is now generally believed, and here it should be noted that this conclusion is not what one would be led to expect from the electron theory, that at the absolute zero of temperature all pure metals would become perfect conductors of electricity. Consequently it follows that, in the economical transmission of electrical energy, low temperature is as important as high chemical purity, especially too as the greater the purity of the metal the greater is its temperature co-efficient of resistance.

There is an important connection between the electrical and thermal conductivities of metals. If the metals are arranged in the order of their conductivities for electricity and heat respectively, it will be found that the sequence is almost identical in both cases, although there are a few notable exceptions which cannot be disregarded. In a large number of cases, too, the ratio of the electrical to the thermal conductivity is constant at the same temperatures, as Wiedemann and Franz were the first to point out, although here again well marked exceptions occur of which account must be taken. Thus while the electrical conductivity of aluminium and also of nickel decreases with ascending temperature, the thermal conductivity of the latter decreases, whilst that of the former increases, circumstances, as it happens, which favour each metal for the particular uses to which it is commonly applied. These facts could, and probably would, have been predicted from the electron theory, had they not been discovered previously.

The study of the electrical conductivity of alloys may be said to have commenced about half a century ago, when Matthiessen published his valuable researches upon this subject, in which he showed that the conductivity of alloys is not, as a rule, an additive property dependent simply upon the percentage composition, but that it is a property dependent also upon the constitution. Since that time the study has made great progress, and our present day knowledge of the conductivity of alloys is remarkably complete. We have just said that the connection between conductivity and chemical composition is not, in general, a linear function of the latter, and the reason

that it is not is primarily because so few of the metals are mutually insoluable in the solid state, or, in other words, incapable of forming solid solutions. In the case of a true eutectiferous series, in which each alloy throughout the range from 0 to 100 per cent. of either of the component metals consists solely of a mechanical mixture or conglomerate of the component metals, the conductivity composition curve is, as might be expected, approximately a straight line. The zinc tin series furnishes one of the comparatively rare examples of this, the simplest relationship possible. (Fig. 1.)

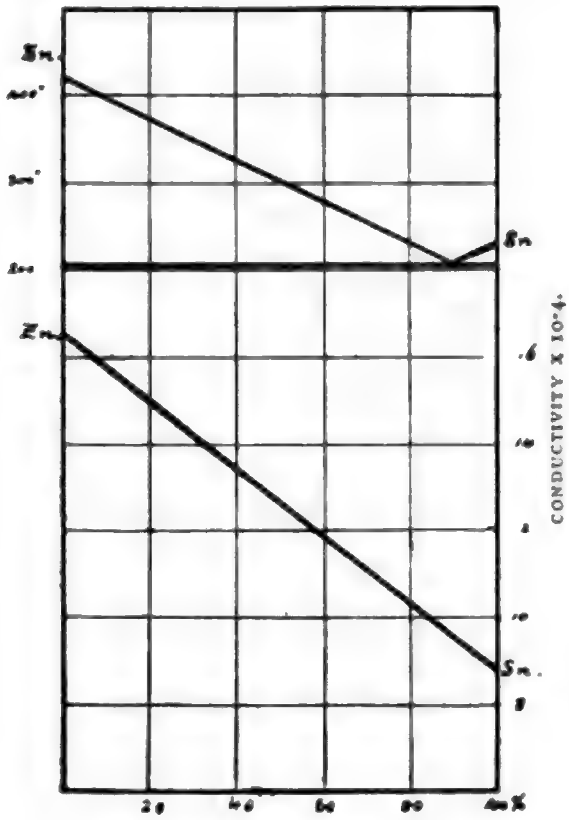



FIG. 1.—(SCHULZ).

Just as certain of the pure metals owe their practical utility largely to their high conductivity, so also certain of the alloys are of industrial value for the opposite reason, namely, on account of their high resistance. And from this standpoint, by far the most important class of alloys is that in which the constituent metals enter into solid solution with one another, all the well known resistance alloys being included in this category. In every case in which the added metal forms a solid solution with that metal which is in excess, the conductivity drops rapidly, no matter whether the added metal is in itself a better conductor or not. The addition of silver to gold, for instance, lowers the conductivity of the latter to an almost surprising extent, when it is remembered that silver is, when pure, a considerably better conductor than gold. (Fig. 2.) The reason is that these metals form solid solutions mutually.

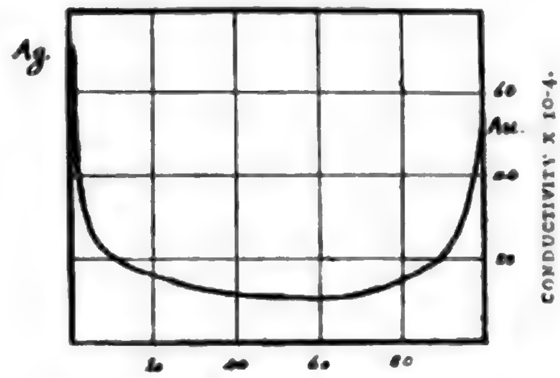



FIG 2.—MATTHIESSEN.

The copper nickel alloys consist of a continuous series of solid solutions, and rank amongst the important resistance alloys. (Fig. 3.) The well known alloy, Constantan, contains 60 per cent. Cu. and 40 per cent. Ni., and has a specific resistance, roughly, 30 times that of pure copper. An interesting experiment was described last year by Messrs. Bruni and Meneghini, who coated a nickel wire electrolytically with copper to such a thickness that the two metals were in the same proportions as in Constantan. The compound wire thus formed was then maintained at a temperature of about 1,000° C. for nearly a week, and its resistance, which was 0·0260 Ohms at the start, was measured at intervals. Diffusion occurred, the copper and nickel mutually went into solid solution, and at the same time the resistance continually rose, until it became constant at 0.2105 Ohms. It was then proved by analysis that the wire had been converted into Constantan, and that its composition was throughout quite uniform. A very important characteristic of solid solutions is their exceedingly small co-efficient of change of conductivity, with temperature. As in the case of pure metals it is negative, that is to say, the conductivity of alloys

in general, whether solid solutions or not, falls as their temperature rises, and there is usually, but not invariably, a remarkably close similarity between the temperature co-efficient and the conductivity curves. The copper nickel alloys afford a good illustration of this. (Fig. 3.) Note the low value of the temperature co-efficient of Constantan, scarcely the 1-100th part of that of pure copper.

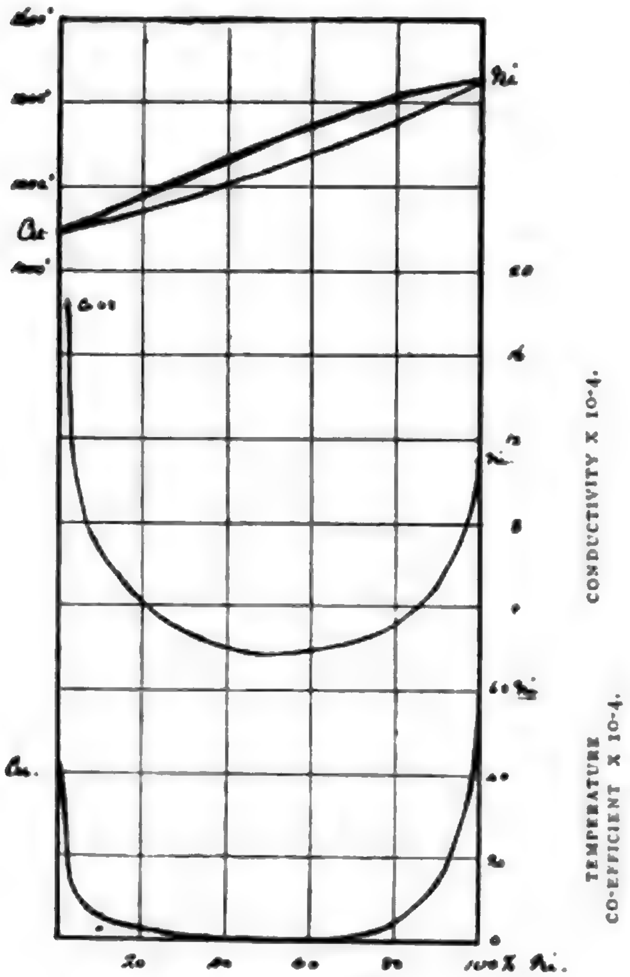


FIG. 3.—(FEUSSNER.)

The most complex type of conductivity arises when the component metals form inter-metallic compounds. The occurrence of an inter-metallic compound is always well shown on the conductivity curve, usually as a peak or cusp, but sometimes only as a break or abrupt change of direction. Magnesium and tin, for example, form one compound, $Mg_2Sn$, which is very sharply and accurately defined on the conductivity curve. (Fig. 4.) The latter, moreover, shows plainly that tin is appreciably soluble in solid magnesium, although the equilibrium diagram would not lead one to suspect it.

Dr. Guertler considers that the existence of a cusp on the conductivity curve is a reliable indication of the occurrence of a true chemical compound, although the absence of one cannot be taken as proof of the absence of a compound. The three types of conductivity curves, just described, namely, those for a eutectiferous series,

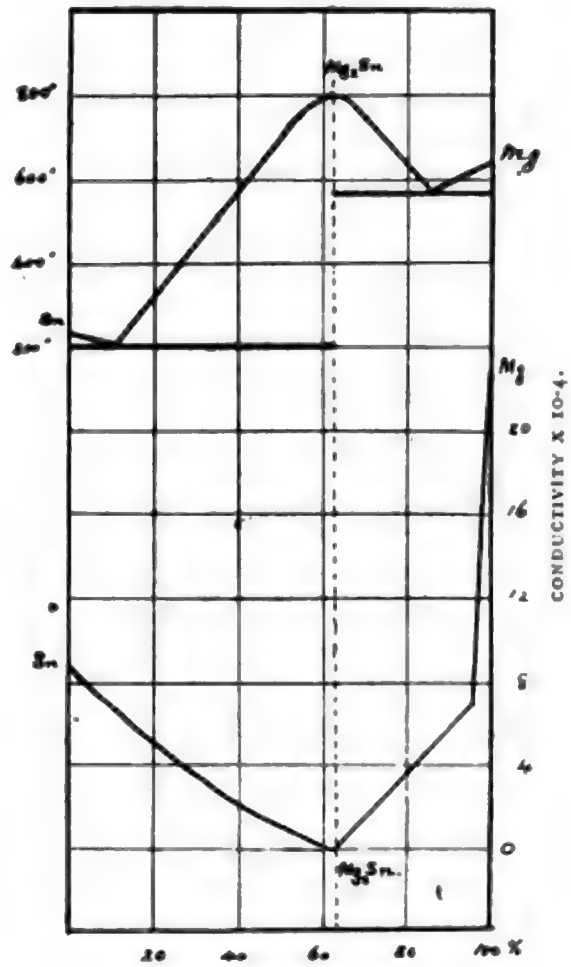


FIG. 4.—(STEPANOFF.)

for a continuous series of solid solutions, and for a series in which one compound is present, are the fundamental types, and the majority of conductivity curves met with, although they may at first sight appear much more complicated, will be found when carefully analysed to consist invariably of combinations of these simple types. The general form of the temperature-co-efficient curves is much less stereotyped, although it usually follows that of the conductivity curves closely. It is noteworthy that whilst the temperature-co-efficient of inter-metallic

compounds is frequently of the same order of magnitude as that of the constituent metals, the conductivity is always considerably less. Consequently, as Dr. Guertler has pointed out in a recent paper, we cannot hope to discover an alloy the conductivity of which shall be greater than that of the constituent metal of higher or highest conductivity. But it must not be lost sight of that the pure metals cannot always be employed as conductors, owing to their relatively low tenacities, and where this is the case, and an alloy has to be used, it is most important to know which combinations of metals will be the most suitable to employ, both from the point of view of conductivity and of tensile strength, etc.

# Current Topics

**New Battleships.**

ACCORDING to the "Globe," a new type of "fast battleship" is in contemplation, and a large staff of draughtsmen at the Admiralty is at present engaged on designs. These vessels will, it is stated, combine the principal features of the battleship and the battle cruiser. It is probable that the armament will consist of eight 15 inch guns together with sixteen 6 inch, which will be the most powerful combination of gun power yet seen. The armour protection will also embody important advances on present practice. The advent of the battle cruiser, of course, rendered such a combination more or less certain, and in this projected type the greatest efficiency of gun power and speed will be combined. These vessels may be expected to be laid down in the autumn.

**Small Motor Driven Refrigerators for Valley Loads.**

NOW that central station engineers are casting about for every means whereby they may increase the day loads and level up the load factors of their plant, it is suggested that more attention should be paid to small motor-driven refrigerating machines than has hitherto been the case. To mention a few of the opportunities for such machines, we may instance the cold storage required by butchers, dairies, creameries, hotels, hospitals and bottling stores. The majority of these are at present supplied with block ice, and in the average case the saving to be effected by the

adoption of motor driven refrigerating machines would amount to about half the cost of the ice method. Neglecting the trades requiring larger plant—such as breweries, etc., motor powers up to 5 h.p. would meet the requirements of most of these cases, depending upon the ice making or cold storage capacity required.

The machine should be compact and demand a minimum of attention in operation. It could, in fact, be made to operate automatically by the temperature change without much difficulty. It would seem that an enterprising firm who developed a special line of such machines expressly for motor drives, and who issued attractive advertising literature for dissemination to the central station business-getting departments, should reap a rich harvest by such action, and it may also be pointed out that the market for their product would not be confined to "mains" consumers, but that it would also appeal to a large number of electricity users who generate their own current, such as large residences, hotels, farms, and so on.

### By-Product Coke Ovens.

THE *Times* recently gave some interesting details *re* by-product coke ovens showing that considerable progress is being made in this direction.

In Yorkshire, which is the second coke-making county in England, the tonnage produced being exceeded only in Durham, there were in operation in 1911 no fewer than 3,539 beehive ovens dealing with approximately 2,000,000 tons of coal annually. In view of the enormous waste thereby involved owing to the loss of the valuable by-products, it is satisfactory to note that at many collieries beehive ovens are being abolished and modern types of by-product recovery ovens erected in their stead.

The Lowmoor Company, Lowmoor, near Bradford, an old firm of iron makers, are just making the change to by-product ovens, and in the first instance the installation is to consist of a battery of 25 Koppers regenerative ovens, with plant for tar, sulphate of ammonia, and benzol. To begin with, the by-product plant, which is arranged for subsequent extension, will be made capable of dealing with the gases from 50 ovens. The installation is also to include a coal compressing and charging plant comprising a fixed stamping station and a combined coal-charging and coke-pushing engine. The coal will be delivered to the trough of the charging machine by means of a scraper conveyor from the storage bunker, and will be compressed by a magnetic stamper operated by an 8 H.P. motor. The charging and pushing machine is to be electrically operated by means of a 40 H.P. motor. A coal service hopper of 150 tons capacity is to be erected to work in conjunction with an existing storage bunker. The coke will be discharged upon an inclined bench arranged to facilitate the loading of the coke into barrows. For quenching the coke a Darby patent quencher is provided supplied with water at a pressure of 80 lb. per square inch.

The Tinsley Park Colliery Company, of Sheffield, already have a battery of Simon-Carvès recovery ovens at work, but they are making additions to their coking plant and are installing 40 Koppers regenerative ovens with by-product plant for dealing with the gases from 50 ovens and recovery of crude benzol. The subsidiary plant includes a service bunker of 600 tons capacity furnished with an elevator and distributing conveyor, an electrically-operated combined coal-compressing and coke-discharging machine, cooling and quenching water pumps, and a water cooling frame.

In this connection we would draw attention to the series of articles we have just published on Mechanical Handling of Coke, which will prove of interest to those about to enlarge old, or install new, plant.

### A Large Storage Battery.

WHAT is said to be the largest storage battery in the world is installed at the plant of the Consolidated Gas, Electric Light and Power Company's plant at Balti-

more, Maryland. This battery consists of 152 cells, each containing 133 type "H" Exide plates, or a total of 20,216 plates. The capacity of this battery is 44,000 amperes for six minutes, or approximately 9,000 kilowatt, the total weight of the installation being in excess of 1,000,000 pounds. The battery is used as a stand-by.

**Remarkable Feed Water Heater.**

NEWS of another piece of power plant apparatus which is the largest of its kind comes from the United States, the home of the largest things. In this case it is a feed water heater of the closed type which has been installed by the Boston Edison Illuminating Company. This heater was manufactured by the Whitlock Coil Pipe Company, of Hartford, Connecticut, and has the extremely large capacity of 20,000 horse power. The water to be heated is passed through copper tubing over which the heating steam is directed. The copper tube inside the heater is almost one mile in length. The shell is built up of boiler iron with single rivetted lap joints on the circumferential seams, and butt strap joints on the longitudinal seams. The general design of the heater is along the lines of the "American Standard" heaters constructed by the Whitlock Company.

## TOOTHED GEARING.

*To the Editor.*

DEAR SIR,—We noticed on page 784 of your June issue an article, entitled "Toothed Gears for Electric Motor Drives," but cannot at all agree with the contentions put forward by the writer of the article, who in stating that double helical gears are costly in comparison with straight cut gears, entirely overlooks the facts that with double helical gears smaller sizes can be used, very much higher ratios can be obtained, and that velocities can generally be kept down, owing to the small diameters and wide face-widths which can be arranged. The diameter of a double helical pinion is usually limited only by the diameter of shaft necessary for rigidity. Owing to the very much larger ratios possible it frequently happens that a single reduction double helical set can be put in the place of a double reduction straight cut set, thus saving a considerable amount of space and an intermediate shaft with its bearing and consequent losses in efficiency.

The limiting velocity of 1,000 ft. per minute, which he gives for straight cut gears if the vibration is to be kept within reasonable limits, does not apply to double helical gears, as owing to the continuous engagement of the teeth of the latter, vibration is reduced to a minimum even at high velocities.

We further notice he states that neither double helical gears nor worm gears admit of any end-play of the motor. This remark is certainly true as far as the latter gears are concerned, but not the former, as is demonstrated in the large number of instances in which these gears are running successfully with pinions mounted directly on the motor shafts. His contention that end-play is essential and is such a very important point, is interesting, in view of the fact that a large number of motor makers during recent years have employed ball bearings even for continuous current motors of large sizes. As must be well known to all users of ball bearings, their use precludes the possibility of end movement of the armature more effectively than double helical gearing possibly can.

A more thorough examination into the facts of these drives will, we are sure, convince your readers that the statement that it is more economical in the long run to employ slow speed motors, is a fallacy, and that by far the cheapest and soundest proposition is to instal high speed motors with double helical gears.—Yours faithfully,

THE POWER PLANT CO., LTD.,
West Drayton, Middlesex.

# BOOK NEWS

**Trade Waste Waters; Their Nature and Disposal.**

By H. Maclean Wilson, M.D., B.Sc., Chief Inspector, West Riding of Yorkshire Rivers Board, and H. T. Calvert, M.Sc., Ph.D., F.I.C. Published by Charles Griffin and Co. Price 18s. net.

This work presents in a concise form the material gathered by the authors during their many years' experience of the working of the Rivers Pollution Prevention Acts. It describes trade processes so far as necessary to show the origin and nature of polluting waste liquids, and gives means found suitable for the purification of such liquids. It may be at once said that the work is authoritative and covers the problems in question in a thorough and practical manner and is certain to be consulted with advantage by municipal engineers, manufacturers, river conservancy authorities, and others. After reviewing the historical and legal aspect of the problems of rivers pollution, the authors deal in turn with the wastes from the coal trade, gas manufacture, grain washing, malting, brewing and distilling, the leather, paper, and textile trades, and sundry other manufacturing processes. A chapter is also devoted to pumps, screens, tanks, filters, and other apparatus for the purification of wastes. The discharge of trade waste waters to public sewers, and methods of analysis and limits of impurity form the concluding pages. There appears to be no mention of the great trouble now common in regard to the access of *petrol* and waste motor oil into sewers and watercourses from garages and similar washings off road surfaces—a subject which we think might properly have found a place in a volume devoted to "trade wastes." This, however, does not detract from the great mass of technical information which has been so well put forward by the authors, who, on every page exhibit that complete mastery of their subject such as is only to be acquired by many years of practical experience. For example, on p. 274, in regard to the much abused question of treatment of sewage on land, the experience of the writers enables them to say that "Where there is a sufficient area of suitable *land* it is better than any filter." With this authoritative opinion we are able to heartily agree, but not so do the exclusive enthusiasts of the "bacteria bed." If space permitted many other criticisms exhibiting the great *practical* knowledge of the authors could be cited. The book is admirably illustrated with 74 well drawn illustrations, and is well suited to the requirements of the municipal, sewage, and rivers' pollution engineer.

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**Outline of Industrial Chemistry—Iron and Steel.**

An introductory text book for Engineers and Metallurgists. By O. T. Hudson, M.Sc., A.R.C.S., Lecturer on Metallography, Birmingham University). Constable and Co., Ltd., London, 1913.

This little work is a very successful attempt within the limit of 169 pages to present to its readers the more important principles of the metallurgy of iron and steel.

Its able and academic treatment of subject matter is focussed upon the constitution of steel and cast iron, with the mechanical and heat effects in the properties and allies.

The range and compass of this small book is admirably in perspective and in relative importance to the main facts.

The subject matter of the different chapters is copiously illustrated, and all that is required to be known of iron and steel in theory is brought up-to-date in a readable and interesting manner. To the student of engineering and metallurgy it should prove of great utility in instructing him in the main facts of the subject.

The second section deals with the corrosion of iron and steel, a subject of particular and recent interest

which is most ably treated at length by Guy D. Bengough, M.A., D.S.C., and as this book forms one of a series edited by the above able exponent, the knowledge imparted upon corrosion is from an authoritative source.

Two or three defects may be noted. In our opinion, the description of iron smelting is rather meagre, as also is electric smelting, and we should have liked to have heard more on the different methods of fusion welding under heading welding. We do not, however, like to find fault with such an excellent attempt to impart the chief principles of iron and steel in what is claimed only to be an elementary work, but we can safely say that it more than justifies any such claim and we cordially recommend its perusal to our readers or any one personally interested.

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**Modern Pumping and Hydraulic Machinery.**

By Edward Butler. 18s. net. London: Ch. Griffin and Co. 1913.

This is a copiously illustrated descriptive account of an immense variety of pumps from the Cornish to to the many fancy types of pumps which crop up day by day. There is also a section on the boring of wells which seems a little out of place and a final section on turbines and pelton wheels. The book is up-to-date, for it describes the Chingford pumps of Humphrey.

In the historical portion there is no reference to the water pressure pumps of Westgarth and Smeaton, Jünkers and Reichanbeach, or the later improved pumps of Richard Trevithick used so much in lead mines. This book does not deal with water engineering to any extent, but is descriptive without being critical, nor does it go much into detail. Some writers seem to be very much impressed with the air lift pump. The author of this book sees its extreme efficiency, and he is quite right right for the air lift should only be used as a last resource. It has its field, but it is not by any means suitable for general work, and it has the great disadvantage of producing severe corrosion of iron and steel for the dissolved air in the pumped water is very strongly corrosive. The air lift pump has been the subject of a considerable amount of foolish talking. Who is going to believe that air forced down a pipe of 200 feet can be made to enter the rising main of water in some special preconcerted manner?

There are chapters on petroleum pumping and heating, boiler feed pumps, injectors, sinking pumps, condensor or air pumps, and so on. The volume is very complete for what it is, for the illustrations are very full and numerous.

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**Building Construction.—Vol. II.**

By J. W. Markham, A.R.I.B.A., Hubert A. Satchell, F.R.I.B.A., Prof. F. M. Simpson, F.R.I.B.A., and others. Longmans, Green and Co. London. 1913. 10s. 6d. net.

This is one of the volumes of the series called the Architect's Library, which cover the ground of The History of Architectural Development in three volumes and Building Construction in two volumes. All of them are exceedingly well written by authorities on the various subjects, and are profusely illustrated.

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**Electric Wiring: A Primer for the Use of Wiremen and Students.**

By W. C. Clinton, B.Sc., M.I.E.E. John Murray. London: 1913. 2s.

This is the third edition of this little book, and the fourth time that it has been reprinted, facts which testify to its usefulness. The present edition embodies a new chapter on dynamos and motors is, of course, thoroughly revised and brought up to date.

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**Modern Sanitary Engineering and Plumber's Work.**

Vols. I. and II. By A. Herring-Shaw and H. F. V. Newsome. Longmans, Green & Co. London, 1913. 2s. 6d. each net.

These are two excellent little books of scale drawings, designs and methods of construction, and contain examples of what may be taken as standards of modern requirements.

# SHIPBUILDING AND MANUFACTURING NEWS

### A New Destroyer.

H.M.S. *Haughty*, the first of the four torpedo boat destroyers of the 1912-13 programme being built for the British Admiralty by Messrs. Yarrow & Co., Ltd., Glasgow, was successfully launched on Monday, May 26th.

The *Haughty* is 260 feet long, with a beam of 27 feet 6 inches. The main engines consist of Brown-Curtis turbines, driving two shafts transmitting equal powers, one propeller being fitted on each shaft. Steam is supplied by three of the latest and most improved type of Yarrow boilers, each of which is fitted with Yarrow's patent feed heating and superheating arrangements, and designed for burning oil fuel exclusively.

### Special Testing Machine for the Iron and Steel Industries.

TWO interesting machines have just been installed at Messrs. T. Firth and Sons, Ltd., West Green Works, Sheffield, to prove certain specialities which they produce, a short description of which may be of interest. One is a testing machine for bending, and is specially designed to bend mild steel or wrought iron bars 1¼ in. square round a radius of ¾ inch through 180 degrees, but special tools can be provided to take any size or shape bar up to a maximum diameter of 1¼ inch. The structure consists of a cast iron hydraulic cylinder and ram, which has a 12 in. stroke. The cylinder is designed to work with a pressure of ½-ton per square inch, and in order to carry the crosshead, four mild steel columns are secured to the cylinder. The bending attachment consists of a plunger and cast-iron dogs, the dogs are attached to the ram head, while the plunger is secured to the cross head. At the front end of the dogs are two mild steel rollers which bend the specimen round the plunger.

The other is a coupling testing machine, which has been designed to test couplings for 2 ft. 6 in. to 4 ft. 6 in. in length up to a capacity of 30 tons in tension. This machine consists of a substantial steel bed raised from the ground and supported on strong cast iron legs. At one end of the bed is a cast steel hydraulic cylinder with a cast iron ram giving a stroke of 12 ins. The cylinder is designed to exert a load of 30 tons when with a pressure of ½-ton per square inch on the cylinder. A hydraulic gauge of the dial type is provided, and on this gauge is given the actual stress on the coupling, from 0 to 30 tons by readings of ⅛-ton. At the other end of the bed is an adjustable eye held by a cast steel frame stay. The adjustment on this eye together

with the 12 inch stroke of the ram makes provision for dealing with any length of coupling from 2 ft. 6 in. to 4 ft. 6 in. The machines were tested by an expert before leaving the works of the manufacturers, Messrs. W. and T. Avery, Ltd., of the Soho Foundry, Birmingham

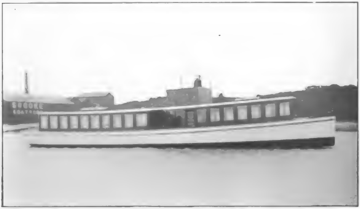
**Passenger Launch for South America.**

THE boat of which a photograph is shown below has just been shipped to South America, and is to ply between two ports in an open river.

She is 60 ft. long by 11 ft. beam, and is built of Uank Teak, of heavy section, the accommodation being split up into first and second class saloons. The engines consist of two 40 h.p. 4 cylinder "Brooke" motors with heavy type, single lever "Brooke" Epicyclic Reverse Gear, with the two engines driving left and right hand propellers, well protected with gunmetal skegs. It will be noted that the control and the steering is carried on the upper deck, and is protected by a mahogany dodger, this in turn carrying an awning for use in the hot climate for which the boat is intended. The lighting of this boat is effected by a dynamo, driven from the port engine, charging accumulators through an automatic switch, above which is fitted a small switchboard. There are 14 lights in all, running on 12 volts. On trial the speed of this boat was just over 11 knots and after completion she was delivered to London Docks under her own power from Lowestoft, meeting bad weather on the journey, but giving an excellent account of herself.

**Marline Spikes.**

By a new patented invention a marline spike is now being made that is a decided improvement upon the usual pattern of which we see so many in use. This new pattern spike is far easier to work, only a quarter or less of the time now being taken is required, and by the shape and careful thought expended upon this article, it can be withdrawn from wire or hemp rope within a few seconds after the strand has been put through. One man and a vice can splice the largest of ropes quite easily. The spikes are made with a hardened steel noze and a taper shaft which admits of easy withdrawal. The shank for two-thirds the way up is grooved with a hollow big enough to take the largest strand, and after inserting the noze through the rope, the spike is pulled forward until just past the groove, and the strand is then




60 FT. TWIN SCREW PASSENGER LAUNCH. BEAM, 11 FT. DEPTH 5 FT. DRAUGHT, 2 FT. 8 INS. BUILT BY J. W. BROOKE & CO., LTD., OF LOWESTOFT.

pushed up the groove and through the rope and the spike withdrawn.

We understand the price is no more than the present article, and is made of good hardened Sheffield steel, any size and width, and should pay for itself within six months in neatness and rapidity of work.

### Flashlight Signals.

An interesting demonstration of the Aga system of railway signalling recently took place at Alexandra Park. The question of the lighting of railway signals has not received the attention which such a subject deserves, and except for quite minor improvements the old plan of lighting by oil lamps is still largely adhered to. It has been found necessary in the scheme of block signalling to make distant signals by day, distinguishable from other signals, and yet during darkness when such a distinction appears to be more necessary there is no visible difference. This applies, of course, more particularly to isolated distant signals, for there are distant signals so located as to be as easily recognised by night as by day.

The need for adopting means of distinguishing distant signals by night is, however, recognised by many leading railway signal engineers, the difficulty arising being the selection of a really suitable and satisfactory method.

Among the many methods, one of the most simple so far introduced, and seemingly the most effective, is the "Aga" Flash Light. This is an invention adapted from the mechanism fitted to "Aga" automatic marine signal lights, and it can be applied to any existing railway signal without interfering in any way with the semaphore action. It will cause the lantern to emit brilliant flashes of light at a regular rate, and the duration of light and dark intervals can be adjusted to any desired periodicity. The demonstration of this system was intended to prove this and so far as it went the results bore out the claim of the makers, the Gas Accumulator Co. (United Kingdom), Ltd., of London. The system has, however, been in service now for several years in unwatched floating lights and despite such severe conditions, we are informed that its record had been perfect. It is claimed, therefore, that in the same way a railway signal fitted with the "Aga" apparatus can be left entirely alone for weeks with absolute safety.

The illuminant employed in the flashlight apparatus is dissolved acetylene, and as the flashing mechanism is rather ingenious we give herewith some details of its working, which will be made clear by reference to the diagram.

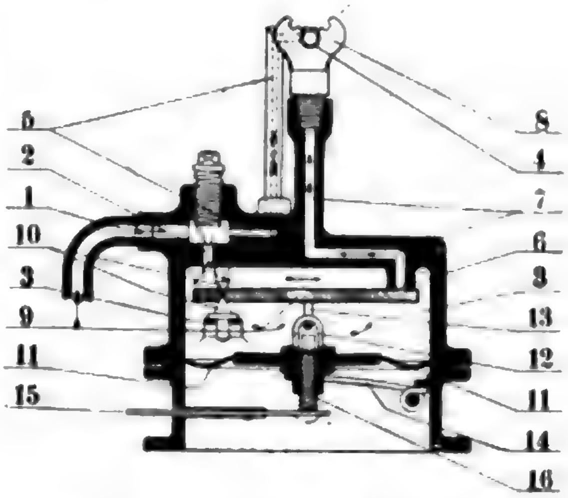



DIAGRAM SHOWING ARRANGEMENTS OF THE "AGA" FLASHER.

The gas from the accumulator is led through a needle valve, which controls the rate of flow, and passing to the flashes distends a diaphragm (11). When this diaphragm has been distended by the gas to a certain point it exerts a downward pressure through the links upon the valve lever which is represented in section. This valve lever is magnetized to a certain extent, and is hinged upon steel points (10) at one end. The other end covers the exit for the gas towards the main burner. As soon as the pressure which the gas upon the diaphragm creates, reaches a definate pitch, this valve lever is pulled away from the gas exit, and the gas contained inside the diaphragm is free to escape to the main burner and will continue to escape until the diaphragm returns to its normal position, when the valve lever will immediately close the exit, and thereby cut off the gas supply to

TWIN SCREW MOTOR VESSEL "EL LOBITO." BUILT BY MESSRS. JOHN J. THORNYCROFT & CO., LTD., OF SOUTHAMPTON.

the burner. The moment this occurs the gas flowing into the diaphragm again begins to distend in the diaphragm and the same cycle of operations is repeated. The result of the valve lever being magnetized is that the pulling away from the gas exit is made extremely quickly, and the closing of the exit is also made in the same manner with the result that the light period is defined by extreme sharpness. The needle valve previously referred to as controlling the inflow of gas controls the length of the dark period as will be seen. By means of the lever 15 the projection of the screw through the centre of the diaphragm, to which this lever is connected, is adjustable within certain small limits. The movement of the lever 15, therefore, influences the amount of idle stroke of the diaphragm which is the same thing as influencing the point at which the gas is discharged to the burner. Adjustment of this screw controls the length of the light period in relation to the dark period, and also, once these proportions are fixed, fixes the number of complete periods occurring in unit time. It remains to be added that a pilot flame is constantly burning, so that the intermittent discharges of gas through the main burner are ignited as soon as they reach the burner outlet. The speed of ignition of acetylene gas enables one to reap the full benefits of the ingenious means employed to make the movement of the main valve sharp and instantaneous. The gas for the pilot burner is conveyed through a by-pass indicated by letter 5, and the pilot burner is so arranged to come right in the centre of the main burner, and not to intrude upon the local centre of the main flame.

Among the special advantages claimed for this system are that it imparts an unmistakeable character to the signals to which it is fitted, that it is absolutely reliable, and will work for months without attention, that it can be readily applied to any existing signal, and that it is always available in case of sudden darkness or fog—an important point in itself.

It certainly represents a distinct advance in this branch of railway signal engineering.

### Twin Screw Motor Cargo Vessel, "El Lobito."

The vessel we illustrate above is intended for coasting work, doing moderate distance voyages along the coast of Peru carrying 50 tons (maximum) of cargo, which will consist of cast iron pipe line. She recently completed her trials with a company of

engineers and Admiralty officials on board. The hull has been built on the composite system, having teak planking on galvanised steel framing, and has been built (hull and machinery) under Lloyds supervision throughout; decks are of Kauri pine.

The motors are located in separate watertight compartment between cargo hold and after accommodation; at after end of motor space are fuel tanks of six tons capacity or paraffin. The top tank is used to give gravity feed to the motors, fuel being pumped up from other tanks by a semi-rotary pump. For working cargo an electric and hand winch has been fitted on upper deck forward, capable of lifting up to 2 tons. Current is obtained from electric dynamo fitted in motor room. A strong pitch pine derrick is fitted to foremast for running cargo.

To add to the appearance of vessel, and for facilitating the exhaust leads a funnel has been fitted abaft bridge. This arrangement has been found to be the most satisfactory as it not only simplifies the exhaust arrangements by putting the silencer in funnel, but ventilates the motor room, and also keeps the heat well away from that compartment.

The vessel is steered from the bridge by means of Archer's patent hand steering gear, and is also fitted with hand capstan forward for working ships' cables.

The machinery consists of two sets of Messrs. Thornycroft's S/4 type paraffin engines, having four cylinders 8½ in. diam. by 12 in. stroke, and developing 100 h.p. on the brake at 550 revolutions per minute. In point of fact in this vessel a speed of ½ knot over the 8½ knots guaranteed was obtained with the engines running at 470 revolutions per minute, and consequently the speed was obtained without unduly forcing the machinery. As is well-known, paraffin engines give best economy at about ¾ full power, and this is borne out in the case of this vessel, her consumption of fuel being about 18 gallons per hour at about 8¾ knots. An auxiliary set is provided for driving an electric light engine, and an auxiliary air compressor. This last is only a standby, as there is a small compressor on each main engine, for charging the bottles, and it is only in the unlikely event of air leaking away when the boat is laid up that the auxiliary compressor is required. Reversing is obtained by an epicyclic reversing gear, fitted at the after end of the engine.

*El Lobito* is capable of making the voyage out to Lobitos, Peru—a distance of 10,135 miles—under her own power. Ample fuel is easily carried for the longest run on this voyage at full speed, without utilising the sails. It is noteworthy that the fuel consumption at 8 knots (obtained with one engine only) is only ·8 or ·9 of a ton per day, giving a radius of action on 50 tons of over 10,000 miles.

She was built for the Lobitos Oilfields, Ltd., by John I. Thornycroft & Co., Ltd., of Southampton.

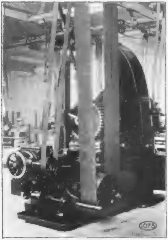
### M.S. "Fordonian."

We are informed that the M.S. *Fordonian*, fitted with engines built by Messrs. Carel Frères, of Ghent, has successfully completed her maiden voyage to Sydney, Cape Breton. No stops of any kind occurred, a testimony to the satisfactory working of her engines.

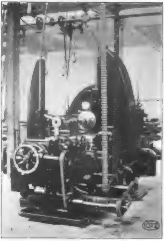
### Chain v. Belt Drives.

An interesting test was recently carried out to compare the comparative efficiencies of belt and chain driving. The test was undertaken by Messrs. Hans Renold, Ltd. (the driving chain manufacturers), of Manchester.

Some little time ago the increase of their business necessitated the installation of two new No. 6 Brown and Sharpe automatic gear-cutting machines. These machines are supplied by the makers with belt drive, and one was accordingly set to work as received, the other being fitted for a chain drive. The two machines were absolutely identical, and so provided an excellent opportunity for investigating the relative values of the two types of drive. Two tests were undertaken; the first in order to obtain the highest possible production; the second, whilst obtaining as nearly as possible the same production, to measure the power required.



MACHINE BELTED UP AS SUPPLIED BY MAKERS.



MACHINE CONVERTED TO CHAIN DRIVE.

The results of the two tests are given below in tabular form :—

TEST 1.—TO OBTAIN HIGHEST PRODUCTION.

| | Belt-Driven Machine. | Chain Driven Machine. |
|---|---|---|
| Highest feed possible .. | 5¼ in. per min. | 5¼ in. per min. |
| Weight of metal removed | 1·66 lb. per min. | 2·68 lbs. per min. |
| Power absorbed .. | 8·3 H.P. | 9·1 H.P. |
| Production Ratio .. | 100 | 160 |
| Power Ratio.. | 100 | 110 |

TEST 2.—TO MEASURE THE POWER AT EQUAL PRODUCTION.

| | Belt Driven Machine. | Chain Driven Machine. |
|---|---|---|
| Highest feed possible which Belt Machine would allow | 3¼ in. per min. | 3¼ in. per min. |
| Weight of metal removed .. | 1·66 lbs. per min. | 1·725 lbs. per min. |
| Power absorbed .. | 8·3 H.P. | 7·1 H.P. |
| Production Ratio .. | 100 | 104 |
| Power Ratio | 100 | 85·6 |

In these tests, therefore, the chain-driven machine gave 60 per cent. more output for 10 per cent. more power, and on the other hand required 14½ per cent. less power at an equal output.

It is claimed, too, that there is a large reduction in the cost of tools on chain-driven machines since the cutters last longer and require less grinding ; moreover, as chains are narrower than belts, an economy of light is also effected, whilst the prime cost is practically the same for both.

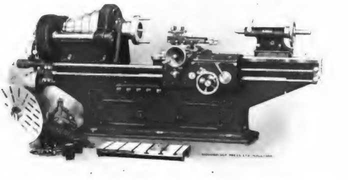
The problem of the most efficient drive is, of course, a most important one, and any facts tending to its solution are always valuable.

### A New Large Capacity Lathe.

THE tool illustrated on next page has been designed specially to meet the requirements of Colonial users and is the outcome of careful investigation by one of the directors of Messrs. Drummond Bros. Ltd., the makers, who personally, visited the Colonies for this purpose.

This lathe, though rated as a 9 in. centre, will take work when required that would in the ordinary way be allotted to a lathe of about double this rating or about 15 in. centre. In the Colonies very long jobs fre-

quently come in which have to be managed somehow. For instance, the repair of artesian well and other boring tubes has often to be undertaken, and for this purpose an abnormally large hole is arranged through other points are well worth the consideration of Colonial customers, who will find that this lathe has the largest capacity for its size of any machine on the market. It is, moreover, simple in its design and needs no special



THE NEW COLONIAL TYPE LATHE, 9 IN. CENTRE AND 9 FT. BED. ALTHOUGH SHOWN HERE WITH BELT DRIVEN FEED, THE LATHE IS NOW FITTED WITH GEAR DRIVE AND THREE SPEED GEAR BOX. MANUFACTURED BY MESSRS. DRUMMOND BROS., LTD., OF WORPLESDON, NEAR GUILDFORD, SURREY.

the spindle which will take an ordinary well tube, and it is arranged to take a simple taper guiding device to render easy the cutting of the usual taper thread on well tubes. The lathe is made with a gap bed, but it is easily powerful enough to turn any work that can be got into it, and the cross slide is long enough to face any such work at one setting. These and several skill to work it. The tailstock is fitted with a new patented device by which the action of locking down brings the head hard up to its lateral guide thus ensuring perfect accuracy. There are many other special features of design which want of space alone prevents our mentioning, but the makers will be glad to supply a detailed specification to all interested.

## NEW CATALOGUES

**Pump Buckets**

The N.P. Pump Bucket was introduced to supply the demand for a piston that would withstand high temperatures and reduce slip. That it has accomplished these objects seems to be demonstrated by the list of well-known and satisfied users given in the booklet just issued by the N.P. Pump Bucket Co., of 11, Queen Victoria Street, London. Some further advantages claimed are that these buckets will expand as they wear and exert a uniform pressure all round the liners; that there is no unnecessary friction when the pump is used for high or low duty, this being automatically adjusted by pressure, and it is simplicity itself with no complicated spring devices to get out of order.

**Packing.**

The various brands of the well-known "Lion" packings are fully

dealt with and illustrated in a booklet we have just received from James Walker & Co., Ltd., of West India Dock Road, London. Rock drill, hydraulic, steam and canvas hose, Balata belting, "Wallico" boiler covering, graphite grease-bricks, sheet jointing, etc., are also included, and the wide range of this firm's productions are well exemplified. The list is well arranged and makes the selection of a suitable packing or any other article required a matter of comparative simplicity.

**Concrete Construction.**

One of the most striking developments in concrete construction is apparently shown by the new Vibrocel system if all the advantages claimed are realised. Certainly the tests already carried out, and results achieved seem to support the claims made. The defects of unvibrated concrete are very marked, and are obvious on all sides. Vibrocel is a vibrated concrete, with the additional advantage that it can be vibrated *in situ* if necessary. The new system is, of course, suitable for all purposes, but more especially for sea walls, harbour works, land reclamation, etc. The blocks can be floated out and sunk in any desired position, and owing to the fact that they can then be filled with cheap materials, the cost is very much less than any existing system. Some very striking comparisons are given in this connection as well as a full description of the system in an illustrated booklet issued by the Vibrocel Co., Ltd., of Eldon Street House, London, E.C.

**Spur Reducing Gear.**

The advantages of Double Helical Gearing are fully set forth in a list just issued by David Brown & Sons (Hudd.), Ltd., of Lockwood, Huddersfield. It is stated that the advantage is most apparent when used for high speed work and it is claimed that shock is entirely eliminated. It is pointed out too, that with helical gear the load can be distributed over as many teeth as necessary by simply varying the face width, or alternately by increasing the angle of the teeth. The mounting of gears is dealt with, and the importance of good substantial bearings as close as possible to the gears is emphasised. The firm makes a complete range of standard cases to transmit any h.p., to accommodate any reduction, and to run at any speed. The list is well illustrated and contains much interesting matter.

**Marine Motors.**

Heavy oil engines of the marine type are fully dealt with in a new booklet issued by Scotts' Shipbuilding and Engineering Co., Ltd., of Greenock. Diesel engines, up to 1,500 H.P., are listed, as well as lighter and auxiliary engines, and the various uses of the fast and slow running types explained. This company are licensees for the F.I.A.T. engines, and their productions are certainly equal to any Diesel engine produced on the Continent.

**Metal Working Machines.**

The Berlin firm of Reiss and Martin A. G., makers of power presses and tools of all kinds for sheet-metal working, have sent us an English abridgment of their catalogue, containing a selection of their presses and tools suitable for the Birmingham trades.

Their sole agents for the Midland Counties and South Wales are Messrs. W. D. Wandbrough, Skelsey and Günther, of 73-74, Exchange Buildings, Birmingham, and Gordon Chambers, 31, Queen Street, Cardiff, who will be pleased to send catalogues or to deal with any enquiries from our readers.

**Centrifugal Pumps.**

We have received from Messrs. Boving & Co., Ltd., a booklet illustrative of their Victoria Turbo pumps. Photographs of interesting installations and full data are given, and one section is devoted to Diesel driven pumping plant.

**Ball Bearings,**

The Skefko Ball Bearing Co., Ltd., of Luton, have sent us an exceptionally well-designed list of their various types of bearings. The advantages claimed are lucidly set forth, and their application to all branches of engineering clearly illustrated.

E. Hall-Brown is, of course, well known in shipping circles, and has just completed his first year as general manager of the Middlesbrough works of Messrs. Richardson, Westgarth and Co., Ltd., having been appointed to that position on the resignation of Mr. Tom Westgarth, in July, 1912. He was educated at St. Paul's Balfour School and Anderson's College, Glasgow. After serving with Messrs Thos. Richardson and Son, Hartlepool, as chief of their scientific department he started as a manufacturer of marine and land engines in Govan, Glasgow, under the style of Hall-Brown, Buttery and Co., in 1892, and then became associated as a partner with A. Roger and Co., shipbuilders, of Port Glasgow and Govan.

He is President of the Institute of Engineers and Shipbuilders in Scotland, Member of the Institutes of Civil Engineers, Mechanical Engineers and Naval Architects, as well as a member of the N.E. Coast Institution of Engineers and Shipbuilders, and of the Institute of Metals.

E. HALL-BROWN, M.INST.C.E., M.I.MECH.E., M.I.N.A.

See reverse side.

**Cassier's Engineering Monthly**

INCORPORATING CASSIER'S MAGAZINE

VOL. XLIV AUGUST, 1913. NO. 2

# RECENT BRITISH LOCOMOTIVE PRACTICE

By Maurice D. Sargeant

QUITE the most noteworthy feature of locomotive engineering in this country at the present time is the widespread adoption of superheated steam in all classes of engines designed for every variety of service, in fact it is almost impossible to refer to any leading British railway now on which superheated steam is not in partial or extended use in express or other services. English locomotive engineers have in the past been criticised for their scepticism anent the claims of compounding as a means of enhancing locomotive efficiency; if this is so, however, they have made ample amends in the reception accorded to superheating in the same connection, as it is rapidly becoming standard practice for all new construction.

The average economies resulting from the use of superheated steam in locomotives are undoubtedly greater than any attained by the various systems of compounding tried on English railways, for the troubles due to lubrication, and excessive wear of piston and valve rods, gland packings, etc., have now been entirely eliminated as a result of the adoption of forced feed lubrication in conjunction with improved design of stuffing boxes, glands, etc. Moreover, the use of piston valves in which the expansion stresses due to the steam temperatures employed—in many cases exceeding 650° Fah.—have been carefully considered and provided for, has removed all valid objections to the use of high superheat under the onerous conditions of locomotive service.

The remarkable success of superheating in this country is nevertheless somewhat striking in view of the very qualified results attained with compounding, in fact, the writer believes it no exaggeration to say that the only English compounds which have given results commercially justifiable are the Smith 3-cylinder engines of the Midland Railway, and it is interesting to note that even on this line non-compound superheater locomotives are stated to show greater relative economy than compounds on similar services. With compound locomotives independent adjustment of cut off in the high and low pressure cylinders is imperative if maximum economy is to be attained, and even then in practice it is extremely difficult to secure economical distribution of power

4-6-0 EXPRESS LOCOMOTIVE, GREAT CENTRAL RAILWAY. DESIGNED BY MR. J. G. ROBINSON, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

between the cylinders without frequent separate adjustments of the cut offs to suit the constant variations of loading characteristic of locomotive operation, which adjustment in the hands of the engineman may, or may not, be efficiently utilised, explaining in some measure the discrepancies between fuel economies obtained on special test runs and in the course of every day working. With superheating the "human element" is eliminated, a net economy in many cases much superior to that of compounding is obtained, while the additional cost and complication is small. Even where runs are short and stops frequent with a consequent lower mean superheat than in express work with more continuous regulator opening, the economies obtained are sufficient to justify the equipment with superheaters of large numbers of tank engines constructed for goods, suburban passenger, and other similar services.

The maintenance of superheater locomotives is not so costly as that of compounds, and on one leading English

4-6-0 EXPRESS LOCOMOTIVE, GREAT EASTERN RAILWAY. DESIGNED BY MR. A. J. HILL, M.INST.C.E., LOCOMOTIVE SUPERINTENDENT.

railway it is said to amount to no more than for non-superheater engines, while any increase on this score is generally effectively counterbalanced by the increased haulage capacity of locomotives so equipped. Marked difference of opinion still prevails amongst engineers as to whether the economies obtained by superheating should be credited to increased boiler or cylinder efficiency, and it would certainly appear that in the light of recent research into the behaviour of highly superheated steam in the cylinders of locomotives, some modifications of widely accepted ideas on the subject of the effect of superheating on cylinder condensation may be necessary. The evidence adduced on these points, however, is of a very conflicting nature, though there is almost complete unanimity of opinion as to the undoubted economies derivable from superheating in locomotive practice.

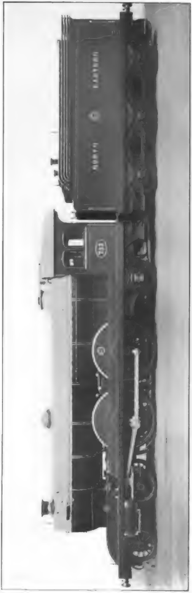
Perhaps after superheating the most striking feature of recent practice is the gradual displacement of the 4-4-2, or "Atlantic" type of express engine, for the heaviest and fastest work by the 4-6-0 design. In an article by Mr. J. F. McIntosh, of the Caledonian Railway, which appeared in CASSIER'S MAGAZINE some three years ago, the question of the superiority of this type of engine over the 4-4-2 was dealt with at some length, and the deficiency of the latter in adhesion weight in proportion to total weight was amply demonstrated. This is undoubtedly the factor responsible for the adoption of the 4-6-0 design for nearly all heavy express work, and only the Great Northern, North Eastern, North British, and London, Brighton and South Coast Railways adhere to the 4-4-2 type for this class of traffic now. For similar reasons for dealing with heavy goods and mineral trains the 8-coupled engine is supplanting on many lines, the standard 6-coupled design which was for so long the standard type for this work, and in goods service, as with express, superheating is being adopted with every success.

To permit of ready comparison of the proportions of the locomotives treated in this article the writer submits the accompanying table, giving particulars of cylinders, wheel diameters, heating and superheating surfaces, weights, etc.

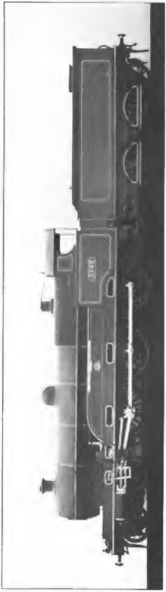
DIMENSIONS OF RECENT BRITISH LOCOMOTIVES.

| Railway. | Wheel Arrangement. | Cylinders. Dia. | Stroke | Wheels, Diameter. Leading. | | Coupled | | Adhesion Weight | | Total Weight. | | Heating Surfaces. Tubes. | Superheater. | Firebox. | Grate Area. | Steam Press | Total Weight of Engine & Tender. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ft. | in. | ft. | in. | T. | Cwt | T. | Cwt. | | | | | | Tons. | Cwt. |
| Gt. Central Railway | 4-6-0 | 21½ | 26 | 3 | 6 | 6 | 9 | 56 | 10 | 75 | 5 | 2210 | 440 | 167 | 26 | 160 | 122 | 11 |
| Ditto | 2-8-0 | 21 | 26 | 3 | 6 | 4 | 8 | 65 | 0 | 72 | 10 | 1538 | 318 | 153 | 26 | 160 | 118 | 13 |
| Gt. North'n Railway | 2-6-0 | 20 | 26 | 3 | 8 | 5 | 8 | 51 | 14 | 61 | 14 | 981 | 302·8 | 137 | 24·5 | 170 | 104 | 16 |
| N. Eastern Railway | 4-4-2 | (3) 16½ | 26 | 3 | 7¼ | 6 | 10 | 39 | 17 | 77 | 2 | 1798·9 | 530·1 | 180 | 27 | 160 | 122 | 8 |
| Ditto | 4-6-0 | 20 | 26 | 3 | 7¼ | 6 | 1¼ | 53 | 6 | 70 | 14 | 1677 | 544·8 | 144 | 23 | 160 | 111 | 16 |
| Gt. West. Railway | 4-6-0 | (4) 14¼ | 26 | 3 | 2 | 6 | 8½ | 55 | 8 | 75 | 12 | 1599·4 | 287 | 155 | 27 | 225 | 115 | 12 |
| Gt. Eastern Railway | 4-6-0 | 20 | 28 | 3 | 3 | 6 | 6 | 44 | 0 | 64 | 0 | 1489·1 | 286·4 | 143·5 | 26·5 | 180 | 103 | 5 |
| L. & N. W. Railway | 4-6-0 | (4) 16 | 26 | 3 | 3 | 6 | 9 | 59 | 0 | 77 | 15 | 1647·2 | 413·6 | 171·2 | 30·5 | 175 | 117 | 0 |

One of the latest and most powerful 4-6-0 designs is the 423 class on the Great Central Railway just turned out from their Gorton shops from the designs of Mr. J. G. Robinson, M.I.C.E., the company's chief mechanical engineer. These locomotives are some 30% more powerful than the 4-4-2, or earlier classes of 4-6-0 engines, possessed by this company, and they are built to the extreme limits of the loading gauge, while as far as possible all details conform to the standard practice of the line. A noteworthy feature is the return to the inside position for the cylinders, previous



4-4-2 THREE CYLINDER EXPRESS LOCOMOTIVE, NORTH EASTERN RAILWAY. DESIGNED BY MR. VINCENT L. RAVEN, M.INST.C.E., CHIEF MECHANICAL ENGINEER

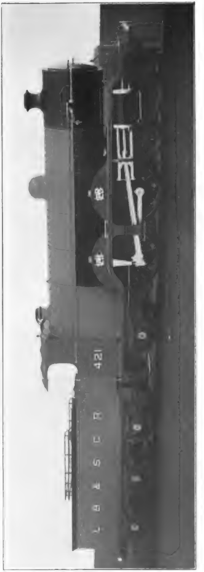


4-6-0 FOUR CYLINDER EXPRESS LOCOMOTIVE, LONDON AND NORTH WESTERN RAILWAY. DESIGNED BY MR. C. J. BOWEN COOKE, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

practice for express locomotives over a period of some eight years on this line having favoured the outside position. Many advantages are to be gained, however, in placing the cylinders inside the frames, as not only is balancing facilitated, making a smoother running engine less destructive to the permanent way, but cylinder radiation losses owing to the greater protection of the cylinders are reduced, while the castings themselves form a useful constructional stay between the frames. A somewhat short connecting rod is, however, unavoidable as the drive must be on the front coupled axle—in this case the rods are 6 ft. 6 in. centres, and have marine type big ends. Piston valves 10 in. diameter having inside admission, distribute the steam supply, being actuated by link motion through rocking shafts, the reversing gear being of the screw type. Robinson's pressure relief valves are fitted to the cylinders which open automatically when the regulator is closed, allowing air to enter and escape from the cylinders, thus preventing a vacuum forming behind the piston, and obviating compression on the return stroke. Pounding in the cylinders when coasting is entirely eliminated by the use of these valves and freer running is obtained, whilst when steam is on, the valves open if the cylinder pressure exceeds that in the valve chest, so preventing excessive compression, and providing good drainage facilities. The adhesion weight of 56 tons 10 cwt. is very ample, and the engines should be enabled to readily accelerate the heaviest expresses. The chief interest of the design, however, is the powerful steam generator provided, which is 5 ft. 6 in. diam. outside, 17 ft. 3 in. long, being pitched 8 ft. 11 in. centre from rail level, and having a Belpaire firebox 8 ft. 6 in. in length, the total heating surface being 2,817 sq. ft., inclusive of a Robinson patent smoke tube superheater of 440 sq. ft. This type of superheater is now standard on the Great Central, and is being adopted by other of the leading companies, its principal feature being the elimination of special joints where the steam elements enter the headers, they being directly expanded therein. Contrary to usual practice no dampers are used for the superheater, a draught retarder consisting of a small steam jet to each element being connected to the blower pipe, which jet serves to retard the draught through the superheater smoke tubes when the blower is on, and thus prevents overheating of the elements when there is no steam in them. This superheater maintains a total temperature in the superheater header of 640-650° Fah., under express conditions. The journal areas are very ample, being for the crankpins 9½ in. diam. by 5 in. long, and for the driving axle boxes 9 in. by 9 in. A 10½m.m. exhaust steam injector is provided on one side of the engine and a 10 m.m. live steam injector on the other; a Wakefield oil pump provides forced lubrication to the cylinders, valves, etc.

This company have also recently introduced some very large and powerful 2-8-0 mineral locomotives to deal with their heavy mineral traffic to the new Immingham Docks. These engines have outside cylinders ½ in. smaller than the express class described. Inside admission piston valves 10 in. diam. of similar design are provided, driven direct by link motion, the steam chests of the two cylinders being bolted together at the centre line providing a powerful frame stay. They have coupled wheels 4 ft. 8 in. diam., and carrying 65 tons of the 72 tons total weight of engine, a very powerful machine results. The boiler provided is 5 ft. diam., 15 ft. long, and is provided with a Robinson superheater of similar design to that already described. The connecting rods drive on to the third pair of coupled wheels in these engines, and therefore, a very long rod is secured. Both types are provided with a standard 6-wheel tender, carrying 5 tons of coal and 4,000 gallons of water.

The Great Northern Railway was the pioneer line in the introduction of the fast "braked" goods trains which are now such a feature of British railway practice, and to deal with these trains,



STANDARD 4-4-2 SUPERHEATER EXPRESS LOCOMOTIVE. LONDON, BRIGHTON AND SOUTH COAST RAILWAY.

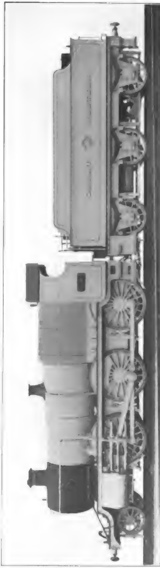
heavy excursion traffic, &c., a new type of 2-6-0 express goods locomotive has just been turned out from their Doncaster works to the designs of Mr. H. N. Gresley, locomotive engineer. The general appearance of these engines is somewhat suggestive of American practice, the running plate being carried above the coupled wheels, there being no splashers. Piston valves 10 ins. diam., with inside admission control, the steam distribution operated by Walschaert gear, which, it may be remarked, is gaining ground considerably in locomotive practice both here and in the U.S.A., while on the Continent it has been practically universal for many years. Like most radial and semi-radial gears, it gives a constant lead at all cut offs, and thus obviates the excessive pre-admission inseparable from early cut off with link motions. It is particularly adapted for locomotives having the valves above the cylinders, the usual position for piston valves. The Great Northern have experimented with the gear on one or two locomotives, and the results having been satisfactory, it has been introduced on these new engines. The boilers provided are equipped with Schmidt smoke-tube superheaters, having 302.8 sq. ft. heating surface, and it will be noted the round topped radial stayed firebox is retained, the Belpaire form not having been introduced on this line so far. Wakefield oil pumps are fitted for lubrication, and tail rods are provided to both piston and valve rods, this being almost universal practice where superheated steam is employed.

This company have also equipped a number of their well-known 4-4-2 express locomotives with Schmidt superheaters, the cylinder dimensions being increased from $18\frac{3}{4}$ ins. by 24 ins., to 20 ins. by 24 ins., to enable greater

expansion ratios to be employed without loss of tractive effort. The steam pressures have been reduced from 175 to 160 lbs. per sq. in. with very beneficial results as regards boiler upkeep. A number of the large eight-coupled mineral engines on this line have also been equipped, a fuel economy of 35·3% having resulted it is stated, and it is interesting to note that balanced slide valves of the Richardson pattern are giving perfectly satisfactory results in these engines with high superheat and forced lubrication. The cylinder diameters have been increased from 19 ins. to 21 ins. in these locomotives.

The North Eastern Railway have recently introduced for their heavy East Coast express traffic some extremely powerful 4-4-2 locomotives from the designs of Mr. Vincent L. Raven, M.I.C.E., their chief mechanical engineer, which have three cylinders. Some 20 altogether have been built, 10 equipped with Schmidt superheaters and 16½ ins. by 26 ins. cylinders, and a boiler pressure of 160 lbs. and ten without superheaters and 15½ ins. by 26 ins. cylinders and 180 lbs. pressure; otherwise the engines are identical and the results of working should prove extremely interesting as demonstrating the exact measure of economy to be obtained from superheating on a very heavy express service involving the covering of some 80½ miles in 91 minutes with loads of 350-400 tons behind the tender. The cylinder castings of these engines are unique, as the three cylinders and their respective piston valve chests are cast in one, thus obviating all bolted joints and securing great rigidity. The exhausts from all three cylinders are diverted into one central blast pipe which latter is equipped with ash ejectors, which remove all ashes accumulating in the smokebox. Three sets of Stephenson link motion actuate the piston valves, which are of the Schmidt patented designs, and all three cylinders drive on to the leading coupled axle, the three connecting rods being 6 ft. 8 ins. between centres, the inside crank-pins being 9 ins. by 5 ins.; the outside 3¾ ins. by 4 ins. The boilers provided are some of the largest now running, and have an outside diam. of 5 ft. 6 ins., and a length of barrel of 15 ft. 10½ ins., the round topped radial stayed firebox being retained in preference to the Belpaire type. The Schmidt superheaters fitted to 10 of the engines are designed to maintain 640° Fah. in the headers, and a Wakefield pump is fitted for forced lubrication on both the superheater and saturated steam engines. The cabs fitted are extremely roomy.

4-6-0 FOUR CYLINDER EXPRESS LOCOMOTIVE, LONDON AND SOUTH WESTERN RAILWAY, FITTED WITH WALSCHAERT VALVE GEAR, PISTON VALVES AND CROSS WATER TUBES IN FIRE BOX.



2-6-0 EXPRESS GOODS LOCOMOTIVE, GREAT WESTERN RAILWAY. DESIGNED BY MR. G. J. CHURCHWARD, M.INST.C.E., CHIEF MECHANICAL ENGINEER. CYLINDERS 18 IN. DIAMETER, 30 IN. STROKE. COUPLED WHEELS 5 FT. 8 IN. DIAMETER.

and have most commodious footplates.

It is notable that while retaining the 4-4-2 design for heavy express work, this company have for some time built powerful 4-6-0 locomotives for dealing with express goods, excursion, and similar traffic. The latest engines of this type turned out have two outside cylinders, 20 ins. by 26 ins., and piston valves. These latter are of the one spring ring type, the rings being kept up to the valve chest liner by steam pressure admitted behind them. Inside or exhaust lap is employed to increase expansion somewhat by delaying release. The boilers of these engines are very large, being 5 ft. 6 ins. outside diam., and 15 ft. in length, and are equipped with Robinson superheaters, designed to maintain 640° Fah., in service. To prevent the rapid cooling of the superheater headers, and elements, which takes place when steam is off, arrangements are provided in these engines to admit steam in small quantities to them when the regulator is closed. A similar arrangement of exhaust passages in the smokebox to that adopted on the express engines is employed, and the blast pipes are fitted with identical ash ejectors. These engines handle smartly booked goods trains of 500-800 tons weight with great success. Brief mention must be made of the extremely fine finish of these locomotives, a quality distinctive of modern practice on this line.

The four-cylinder simple expansion locomotive is now very widely adopted in this country, more especially on the London, and South-Western, Lancashire and Yorkshire, London and North Western, and Great Western Railways, and although a design costly in construction, and upkeep, it possesses very valuable compensating advantages as regards even turning moment and tractive effort, and improved balancing of the reciprocating masses, reducing the size of balance weights required and resultant hammer blow on the track at high speeds. With the inside and outside cranks set at opposites and at right angles to those on the other side of the engine,

the balancing of the reciprocating masses is practically achieved, and engines thus designed run with very marked smoothness at the highest speeds. It is now customary to divide the driving effort over two axles, the most common arrangement being for the inside cylinders to drive the first coupled wheels by a crank axle, and the outside on the second coupled axle by crankpins set in the wheels. The four-cylinder 4-6-0 express locomotives of the Great Western Railway, designed by Mr. G. J. Churchward, M.I.C.E., chief mechanical engineer, are an interesting example of this design and are now this company's standard express class. In these engines the four cylinders are not arranged in line under the smokebox, but the inside pair are over the front bogie axle, and the outside pair over the back; the connecting rod lengths are 7 ft. 10 ins. centres and 8 ft. centres for the inside and outside rods respectively. The steam distribution for all four cylinders is by 8 ins. piston valves, two sets of Walschaert gear driving the inside valves direct, and the outside through horizontal rocking levers pivotted on and passing through apertures in the frames. The most striking feature of these engines is the design of the boilers, which embodies some important departures from usual practice. The barrel is 14 ft. 10 ins. long, and comprises two taper rings, the outside diameter at the front end being 4 ft. 10 13-16 ins., and 5 ft. 6 ins. at the back end, the centre line being 8 ft. 6 ins. from rail level. No dome is provided, but a direct loaded safety-valve is mounted on the second ring. The regulator is situated in the smokebox, the steam pipe to same running the whole length of the boiler, and taking steam from the top of the firebox. The boilers of the latest of these engines are equipped with the Swindon superheater—patented by Mr. Churchward—which is designed for a moderate superheat of 120-130° Fah., and in which careful provision has been made for the ready removal of any defective units without dismantling the superheater. In view of the moderate superheat no augmentation of the cylinder dimensions has been made, and a special form of sight feed lubricator is found to provide adequate lubrication. In an exhaustive paper before the Institution of Mechanical Engineers, in 1906, Mr. Churchward dealt at length with the problems involved in modern locomotive boiler design, and an interesting innovation has just been made on the boilers of this line in the method of introducing the feed, this now being sprayed right into the steam space, the clack valves being situated each side of the safety valve casing. Tests carried out have demonstrated clearly that with the usual boiler feeding arrangements, when the regulator is closed any feed water introduced immediately flows to the bottom of the boiler, *i.e.*, around the firebox side sheets, cooling these in a few moments as much as 100° Fahr. in some cases. By introducing the feed at the highest possible point a more complete mixing with the water already in the boiler coupled with a rapid rise of temperature is secured, and the firebox plates are maintained at a much more uniform heat with a substantial reduction in upkeep costs. The necessity of providing ample circulation round the firebox with the high pressure carried (225 lbs. per sq. in.) has received special attention in the design of these remarkable boilers, and so successful has the new system of "top feed" proved that it is being rapidly fitted to all new locomotives constructed at Swindon works, and to the boilers of existing engines coming in for repairs. The excellent work of one of these locomotives hauling the heavy Cornish Riviera express was analysed at length by Professor W. E. Dalby in his recent paper before the Institution of Mechanical Engineers on "Acceleration and Retardation Diagrams for Trains," in the course of which he commented on the remarkable performance of the engine, and stated that "to exert a draw bar pull of 1¾ tons at 70 miles an hour, corresponding to 730 horse power at the draw bar, is an achievement in locomotive design which it would be difficult to surpass within the limits of the British loading gauge."

Although the average speed of the express trains on the Great Eastern Railway is not particularly high, the train loads are often very considerable, especially in the Continental services via Harwich, and locomotive work of no mean order is called for in their operation. Up till the end of 1911 the largest express locomotives possessed by this Company were of the 4-4-0 type, but some very large and powerful 4-6-0 engines, equipped with superheaters, have now been put in service. Inside cylinders have for many years past been standard practice on this line, and no departure from this has been made in the new machines; they are, however, the first locomotives on the Great Eastern line to be fitted with piston valves, these being placed above the cylinders and operated by link motion through rocking shafts. The boilers of these engines are of very ample proportions, being 5 ft. 1⅛ in. maximum internal diam., and containing a Schmidt superheater of 286·4 sq. ft. surface. The fire-boxes are of the Belpaire pattern, which has been the standard on this line for some time now, the front half of the grate being inclined above the intermediate axle, and the back half horizontal, the area being 26·5 sq. ft. Reversing gear operated by compressed air from the Westinghouse brake pump is provided, with a screw for hand reversal and adjustment of cut off in addition. The working pressure carried is 180 lbs. per sq. in., and the cylinders are 20 in. diam. by 28 in. stroke, as against 19 in. by 26 in. in the 4-4-0 engines. A Wakefield pump operated by lever off the right hand valve rod, provides forced lubrication to the cylinders, valves and piston tail rods. The introduction of these fine locomotives has much facilitated the handling of this Company's heavy express traffic, and a further set have just been turned out of the Stratford works.

The London and North Western Railway have also just introduced some new and extremely powerful 4-6-0 locomotives, constructed from the designs of Mr. C. J. Bowen Cooke, M.I.C.E., their chief mechanical engineer. These engines have four cylinders 16 in. by 26 in., all in line under the smoke-box, and all driving on to the leading coupled axle, the inside cranks being at right angles, and the outside being at 180° to the corresponding inside cranks, and therefore at 90° to each other; almost perfect balance of the reciprocating parts is thus obtained. As in the Great Western engines previously described, two sets of Walschaert gear operate the 8 in. piston valves, the outside valves direct, and the inside valves through the medium of rocking shafts, the gear being outside the frames and thus more readily accessible. The boiler has a mean diam. of 5 ft. 0¾ in., and is 14 ft. 10½ in. long, the firebox of the Belpaire type having a grate area of 30·5 sq. ft. A Schmidt superheater of 24 elements, giving a heating surface of 413·6 sq. ft., is provided, and the boiler is designed for 175 lbs. per sq. in. pressure. Two injectors are provided, one a Gresham and Craven exhaust pattern, and one a live steam, while lubrication is provided by two Wakefield pumps to cylinders, piston rods, valves and valve rods. These engines are a very marked advance on previous London and North Western practice, and with the adhesion weight of 59 tons in conjunction with ample boiler and cylinder power, they will doubtless do some very remarkable work with the West Coast Scotch expresses, probably the heaviest regular express trains running in Great Britain.

Within the limits of a single article it is obviously impossible to chronicle all the new and more powerful designs introduced of late, as a result, doubtless, of increased traffic due to improved trade conditions prevailing. The foregoing, however, are thoroughly representative of recent locomotive engineering, and reveal the manner in which British locomotive engineers are meeting the insistent demands for greater haulage power from their traffic departments. The rapid approach to the maximum dimensions of boiler permissible by structural considerations and loading gauge restrictions has accentuated the need of adopting all possible means of enhancing boiler efficiency, and it must be noted that

extensive experiments with feed-water heating are being carried out on many lines, although, with the exception of the London and South Western, such equipment has not become standard practice on any railway. It is a matter of regret that the prohibitive price of oil fuel has entirely arrested progress in the direction of its substitution for coal for locomotive purposes, and the possibilities it affords of increasing the steaming capacity of existing boilers are, therefore, not available to locomotive engineers. As announced in the Special Oil Power number of CASSIER'S MAGAZINE, however, attempts are now being made to adapt the internal combustion engine to heavy railway traction on the Continent. Obviously the difficulties to be overcome in the application of this type of prime mover to locomotive purposes are extremely formidable, but should they be successfully surmounted—in conjunction with some cheap form of fuel—the introduction of such engines would have a most important bearing on the future of locomotive design, though it is readily apparent the overall efficiency would require to be very considerable to compete with such an economical machine as the modern steam locomotive can justly claim to be.

# A DEVICE TO FACILITATE THE COUPLING OF CRUISING TURBINES.*

By Harold E. Yarrow, A.M.I.N.A.

OWING to the uneconomical performance of turbines when developing powers considerably below full power, attention has recently been directed to improving the economy of vessels when cruising at low speeds by the introduction of special motors such as turbines, internal combustion engines, or reciprocating steam engines. Sir Charles Parsons has already constructed successfully turbine installations having special cruising turbines. Certain difficulties that arise from the use of an additional motor, transmitting its power simultaneously with the main turbine, may render it necessary to use the main turbine and the cruising turbine independently of one another, the vessel being driven by the one or the other, and not by the two in combination. This involves connecting and disconnecting the low-power motor from the main shaft.

The cruising turbine or engine may drive the main shaft through the medium of electrical or hydraulic transmission, or by simply throwing in and out of gear a clutch; the latter arrangement undoubtedly offers advantages, there being no appreciable loss of power, and the increased complication and cost of an electrical or hydraulic transmission are avoided. The use of a friction clutch on board ship may lead to difficulties, especially in view of the comparatively large powers that have to be transmitted. The simpler and more direct method is by throwing in and out of gear a dog clutch, so that the cruising motor can be coupled up or not as desired.

When a high speed is demanded it is contemplated that the main turbine only will be working, and when a cruising speed is required the cruising motor only will be working, the main turbine in this case being simply driven round by the cruising motor. If the cruising motor consists of a steam turbine, the exhaust from it could of course be utilised in the main turbines to assist in the propulsion of the vessel.

* Read before the Institution of Naval Architects.

Fig. 1 represents one arrangement of turbine machinery.

Assuming that a vessel is being propelled at low speed by means of the cruising motor, which would probably convey its power to the main shaft through gearing, and it is desired to increase the speed and propel the vessel by the main turbine, no serious difficulty would be found in throwing the cruising motor out of gear by means of an ordinary well-designed clutch. It is, however, not such an easy matter to make the change from the full-power turbine to the low-power motor, because in this case the clutch has to be put into gear. This can be done by stopping the vessel, but that may not always be permissible, and if it can be avoided it is certainly preferable. On account of the large powers now in use even when cruising, if the two shafts that it is desired to couple together are not rotating at nearly the same speed, it would not be possible to engage the clutch without involving an objectionable shock. On the other hand, if the clutch is put into gear when the shafts are revolving at approximately the same number of revolutions, it is evident no appreciable shock would be caused. It therefore becomes necessary to adopt some device by which the relative speeds of the two shafts can be ascertained; and when they are revolving at practically similar speeds the clutch could be put into gear, and the shafts then connected together.

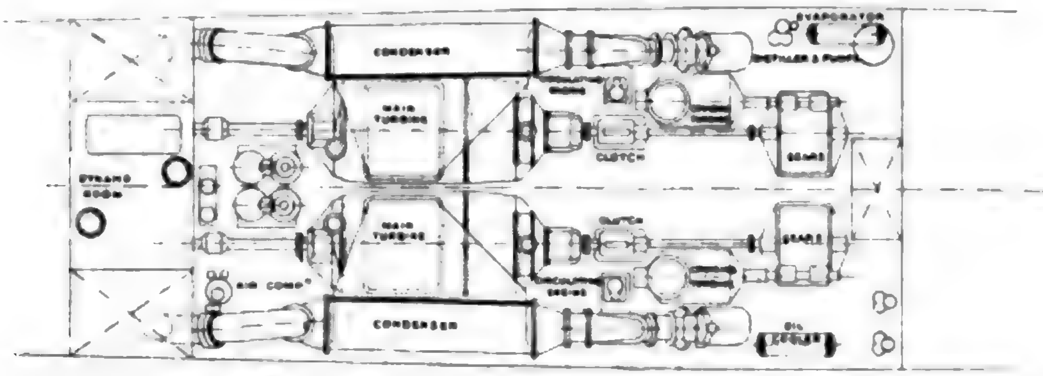


FIG. 1.—ARRANGEMENT OF MAIN TURBINES AND GEARED CRUISING TURBINES WITH CLUTCHES FOR DISCONNECTING CRUISING TURBINES FOR FULL SPEED.

Fig. 2 shows one arrangement pro-

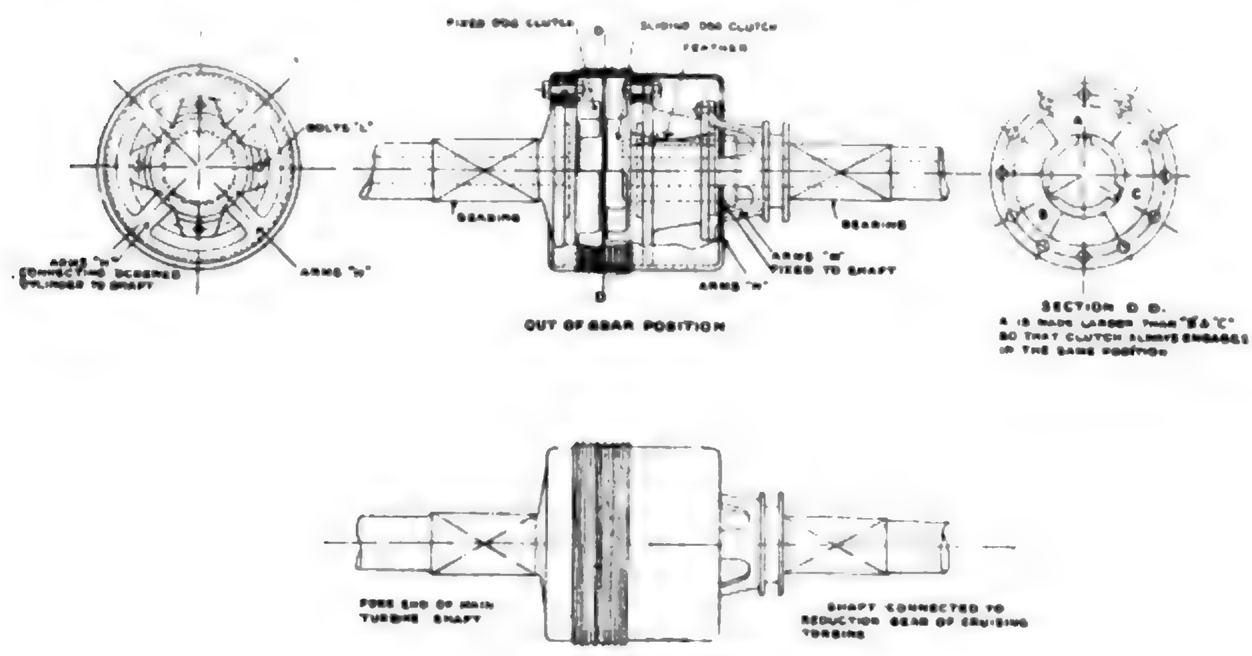



FIG. 2.—PROPOSED COUPLING DEVICE.

posed, from which it will be seen that on the outside of each coupling a screw thread is cut, the threads on both couplings being similar. By watching the thread when the couplings revolve it makes their relative speeds at once apparent, and when the screw threads appear continuous the two couplings will be revolving at tremity a bevel wheel gearing in with another bevel wheel, which latter would be fixed in a revolving frame, and therefore forming a differential gear similar to that used in a motor car. If the two shafts are revolving at the same speed it is evident that the revolving frame will remain stationary, but if there is a difference

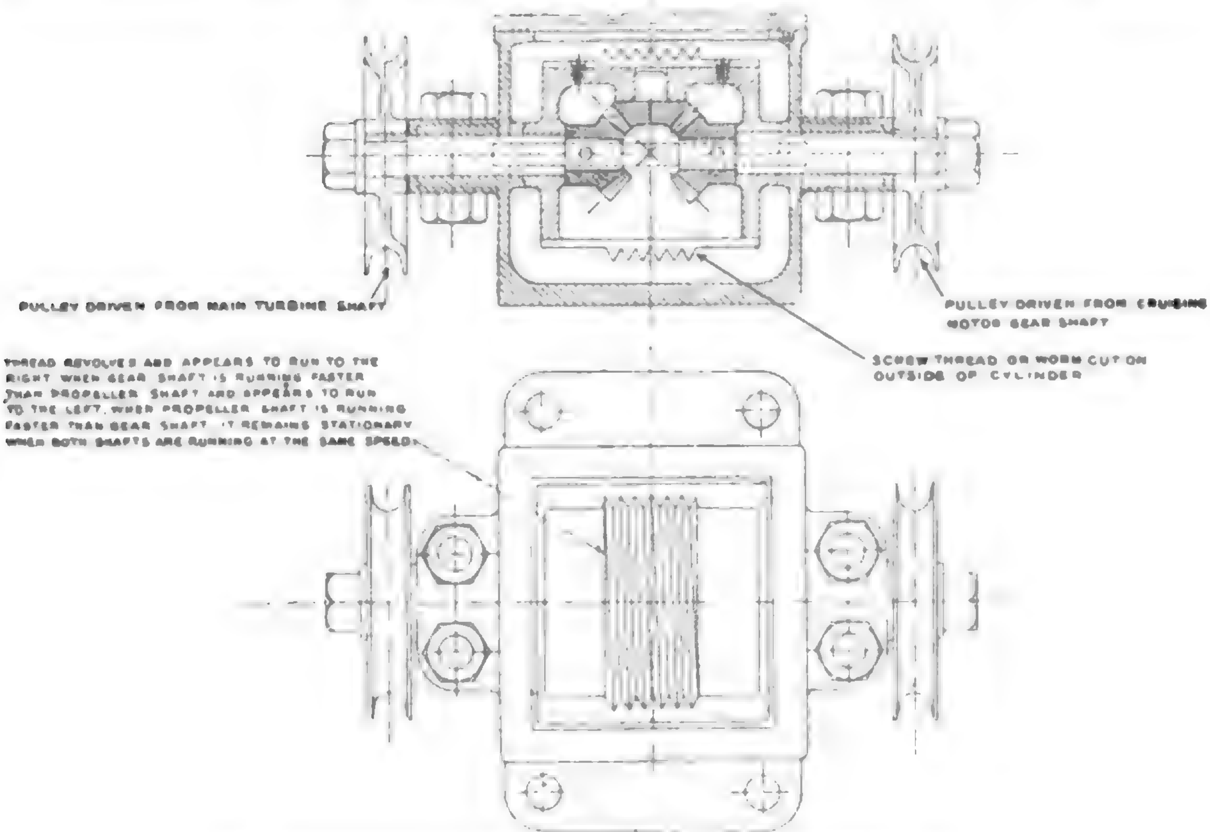



FIG. 3.—ANOTHER METHOD OF CARRYING OUT IDEA ILLUSTRATED IN FIG. 2.

equal speeds. If they are rotating at different speeds the one which is revolving the more rapidly will make the screw thread appear to be travelling faster. The optical effect produced by the rotation of the clutches upon which the screw thread is cut makes the progression of the thread or spiral line in the direction of the axis of rotation readily apparent, the eye at once recognising any difference in speed between the two shafts.

Fig. 3 shows another method of carrying out the same idea. It will be seen that two pulleys are driven from each of the two shafts that it is required to couple together, the pulleys revolving in opposite directions. Each pulley would be attached to a short spindle having at its ex-

in the revolutions of the two shafts the difference will make itself apparent by causing the revolving frame to rotate either in the one direction or the other, depending upon which shaft is travelling faster. On the outside of the revolving frame it will be seen a screw thread is cut so as to make apparent the speed and direction of rotation of the revolving frame. When the speed of the two shafts approximates very closely, the revolving frame will almost stop, and the coupling can be connected with the minimum shock.

Fig. 4 represents another device by which a pointer indicates the relative speeds of the two shafts. Many other devices could be designed for effecting the same object, but it will be admitted

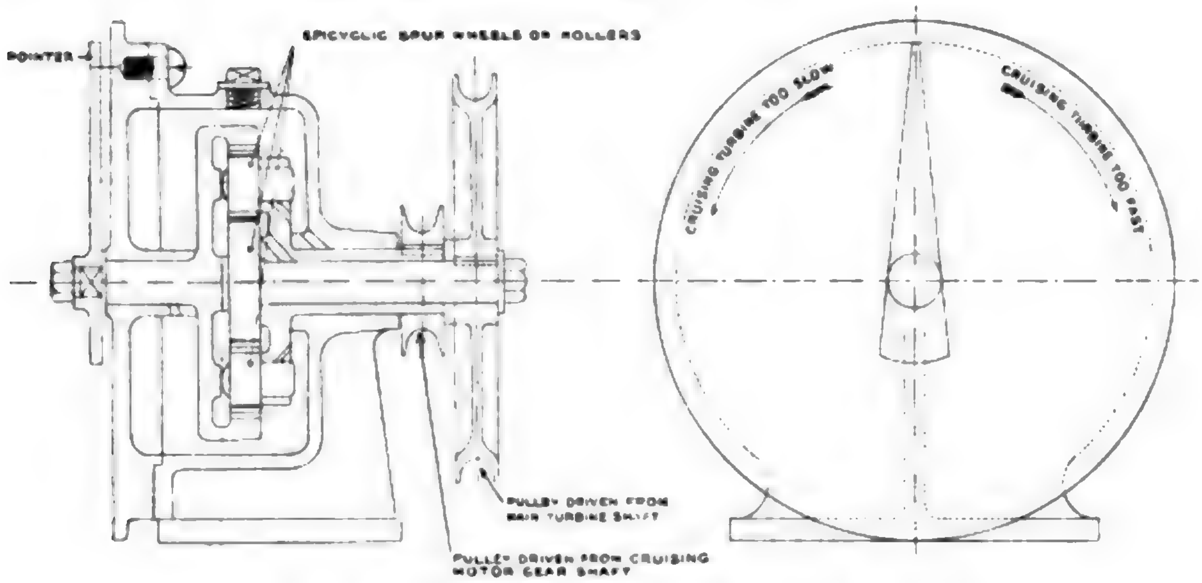



FIG. 4.—POINTER DEVICE FOR INDICATING RELATIVE SPEEDS OF TWO SHAFTS.

that without some means of this kind it would be very difficult to form a correct estimate of the speed of rotation of the two shafts in line with one another. Although such a device has not been fitted by us in any vessels, from trials made in our shops it has been found very easy to determine the proper moment to engage the clutch. With reference to the coupling itself, in which an ordinary dog clutch is used, it is desirable that the two clutches should only be capable of being put into gear, so that the same faces are always in contact with one another, because with the greatest possible accuracy in workmanship it may be found that the work will not be taken up equally by the different surfaces in contact, and the faces of the clutch will readily wear. Therefore, it is submitted that whatever clutch is adopted the same faces should always be in contact, and this can be effected by the projections of the dog clutch being of unequal size. Another point which should be borne in mind in connection with such clutches is to design the bearings which support the shafts close up to the clutches, so that they should not be subjected to unequal wear. This is necessary, because if there is a difference in the amount of wear to which the two bearings are subjected, causing the shafts to get out of line, the want of alignment thus arising between the two clutches will cause movement between them and lead to trouble. For this reason it may be desirable that a certain length of shaft should be interposed between where the power is transmitted and the clutch, which would allow for the unequal wear of the main engine or turbine bearings; while the special bearings which have only to support the weight of the shaft near the clutches may be considered as likely to wear evenly.

The devices which I have had the privilege of describing are, in a great measure, due to my father, Mr. Marriner, and Mr. Cotton, to whom I am further indebted for their help in the preparation of this paper.

# NEW METHODS OF VENTILATION AND THE ADOPTION OF OPEN FANS FOR FORCED DRAUGHT IN STOKEHOLDS

By James Keith, Assoc.M.Inst.C.E., M.Inst.Mech.E.

IN his presidential address before the Physiological Section of the British Association at Dundee during September last, Dr. Leonard Hill dealt with the "Maintenance of Health"; and some of his statements have a considerable bearing on the Ventilation of Tunnels, Mines, Engine Rooms, Workshops, etc., confirming in many respects the conclusions which the writer himself has come to after a life-long study of the Science of Ventilation with all its apparent contradictions and inconsistencies; and the writer desires to place on record a note of the results of several costly series of experiments which have resulted, after a few failures, in efficient and eminently satisfactory working under certain conditions, though the very opposite may occur.

There is no royal road to success in this or any other branch of technical science; but this much is certain, viz., that good ventilation—as so well set forth by Dr. Leonard Hill—cannot be secured in all cases without the expenditure of money and without the aid of experienced experimenters and mechanical energy in some form or other under what may sometimes be thought unnatural conditions. The whole of Dr. Leonard Hill's address will repay perusal not only by engineers but by workers whose health has not hitherto been sufficiently studied, and to whom the bracing effect of pure air would prove of great value; and the following excerpts from the address are of special interest:—

> "All the efforts of the heating and ventilating engineer should be directed towards cooling the air in crowded places and cooling the bodies of the people by setting the air in motion by means of fans."
>
> "The *essentials* required for any good system of ventilation are:—(1) movement, coolness, proper degree of relative moisture of the air; (2) reduction of the mass influence of pathogenic bacteria."
>
> "The chemical purity of the air will be adequately insured by attendance to the *essentials*."

This authoritative pronouncement should carry weight: and it will be found that the "*essentials*" so strongly recommended by Dr. Leonard Hill are part and parcel of the system of ventilation which the writer has adopted after trials on a large scale, of which he believes a movable modified example (but for summer use only) was independently carried out by Professor C. V. Boys, F.R.S., at the rooms in which the soirées of the Royal Society have been given for many years and where the guests previously suffered so much discomfort from insufficiency of fresh air.

In a lecture delivered to the members of the Edinburgh Philosophical Institution in January, 1879, on "Domestic Sanitation," the late Professor Fleeming Jenkin stated that—

> "The ideal condition of comfort and healthiness is that represented by a hillside on a still spring morning, when the sun is shining brightly and there is frost in the air."

Though it may not be possible to attain to this high standard in enclosed places, there need nowadays be no excuse for lack of good ventilation almost anywhere if the most be made of those increased facilities for the economical adoption and the distribu-

tion of cheap electrical power for driving fans.

From a sanitary point of view the "Maintenance of Health" and "Ventilation" are synonymous so far as the necessity of securing a change of air goes, and each person to be in perfect health requires a certain amount of fresh air. Fortunately, less change of air is required in rooms or enclosed places in winter than in summer, as the higher the external temperature, the more air is necessary for comfort even in the open. The value of open-air schools in the improvement of the physique of children has lately been exemplified by the publication of a report by the Manchester Medical Officer of Health, in which it is shown that in the centre of the city the children are on an average 6 lbs. lighter and 3 inches smaller than those of like years who live two miles out and have the advantage of fresh air and sunlight. A report by the School Medical Inspector again shows that the breathing of pure fresh air has a wonderful effect on the physical and mental condition of the child, and indicates that this has been proved in the open-air schools which have already been established in the country near Manchester. The race is to the swift. Twentieth-century knowledge has

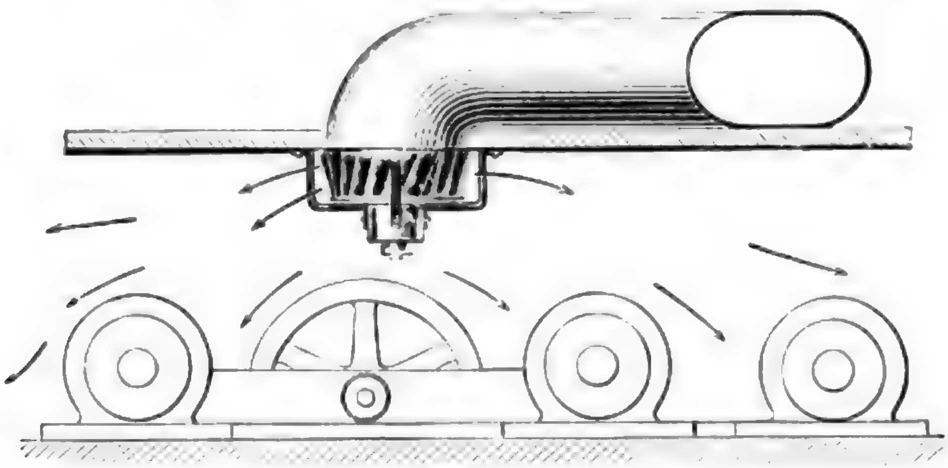


FIG. I.

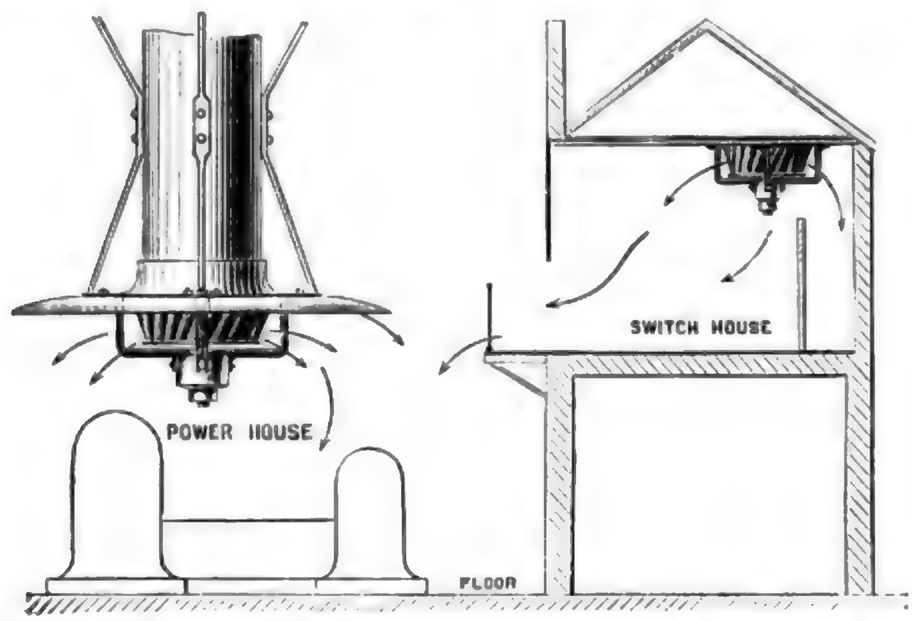



FIG. 2.—PART SECTION POWER HOUSE AND SWITCH-BOARD HOUSE, SAINT DENIS, PARIS, FANS INSTALLED BY MESSRS. BABCOCK AND WILCOX, OF LONDON.
The main building or power house proper shown alongside is not separately ventilated at present, but the diagram indicates how it may be by a series of larger fans being installed throughout its 600 feet length.

taught us that the northern races and those most given to the practice of manly open-air exercises are the healthiest and strongest, and that the dominators of the world and its trade to-day are the people who are furthest advanced in sanitary science. It behoves us, therefore, as a nation to look to our laurels and see that we continue to keep first in everything pertaining towards progression in sanitation and ventilation.

The proper cooling down or ventilation of overheated engine rooms above ground, underground, or underdeck, of electric power stations, "tube" railways, workshops, tunnels, etc., having become one of the problems of the present electric age, can only be solved by the flooding of these rooms or places by fresh air in volume from the outside under slight pressure by fans, and without the use of air-delivery ducts inside. That, at least, is the writer's experience. Positive ventilation again on a new principle appears to the author to be the best means for furnishing fresh air with comfort at all seasons in offices, bedrooms, railway carriages, tramcars, cabins, state rooms, etc. The attention of readers is called to the following new methods for the provision of healthfulness and comfort :—

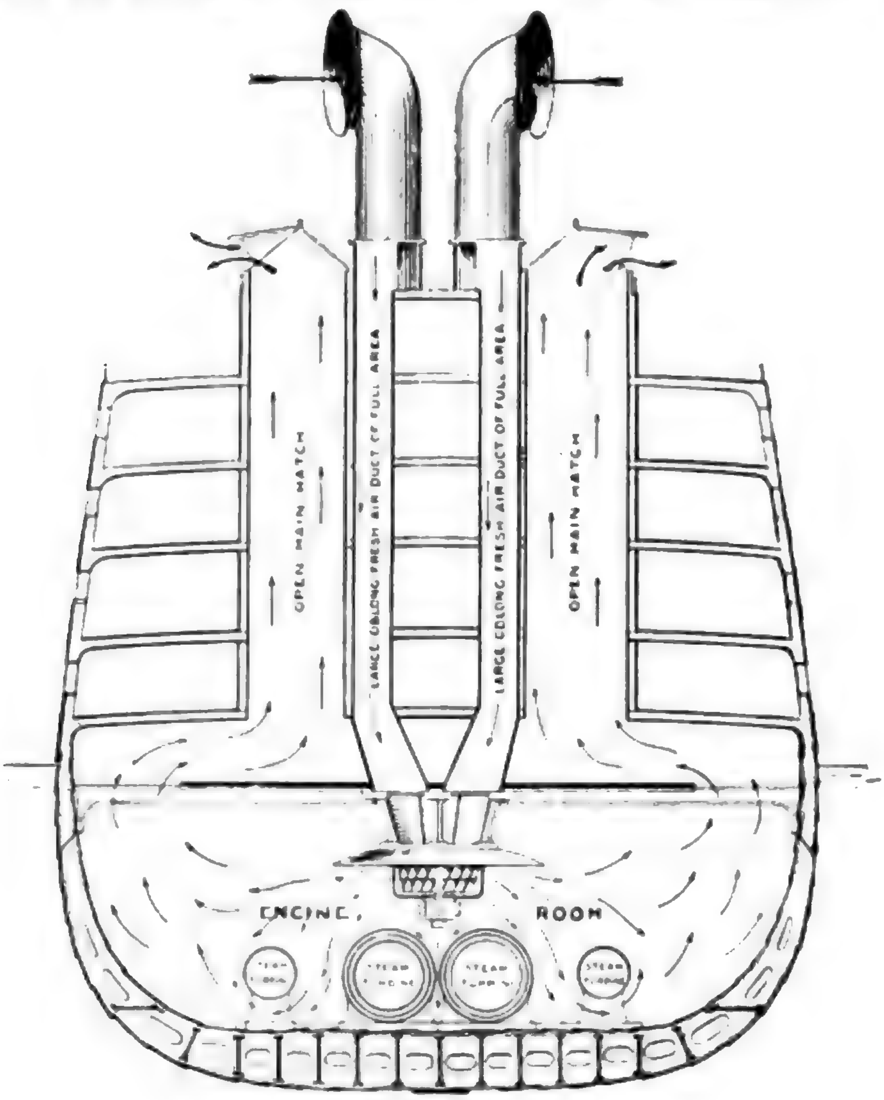



FIG. 3.

1. Among the most important of the cases in which improvements have been effected may be mentioned that of a large underground electric power station in the Singer Building, New York, where the total cubical contents of air (120,000 cubic feet) are changed once every minute, with an expenditure of only 22 horse-power. Three open type fans, each arranged

as shown in Fig. 1, have superseded all other systems hitherto tried in this power house, and secure perfect ventilation without any discomfort from draughts, with much less power than formerly when the minimum inside temperatures ranged from about 100 degrees Fahr. in winter to about 130 degrees Fahr. in summer. The air displaced mostly escapes towards the floor level into the boiler house, thus increasing the ventilation and benefiting the draught of the boiler fires and chimney. A somewhat similar application may be made in the case of a "tube" or railway tunnel station.

2. Another example (Fig. 2) shows a part of the transverse section of a large Continental power house, where a switch-board house about 500 feet in length has been satisfactorily ventilated and cooled down from an abnormally high temperature by ten fans placed in the ceiling of switch-board house as shown. In this case each fan has a 25 inch diameter air inlet, and delivers at 700 revolutions per minute, 9,000 cubic feet of air per minute at an expenditure of 1,400 watts. By means of the ten fans a change of 90,000 cubic feet of air per minute is thus effected in the switch-board house for 14,000 watts, and the point to be noticed is that the cool air distributed and sent into the power house by the new type of open fan in such big volume does not produce unpleasant currents.

It may here be noted that the data given for the Singer Building Power House installation have been vouched for by Mr. W. Carlile Wallace, of New York, Assoc.M.Inst. C.E., M.Inst.N.A.,Eng., who made tests with the assistance of the engineering staff to the full satisfaction of the chief engineer of the Singer Building and the Singer Company. The installation has been in full use night and day with the exception of Sundays for more than two years past.

Again, the fans at work in the switch-board house of Saint Denis Power House were installed and tested to the satisfaction of the French representatives of Babcock and Wilcox, Ltd., of London.

3. Transverse section through engine room of one of the great Transatlantic Liners (Fig. 3), illustrating the application of the new method of ventilation for flooding the engine room with cool, fresh air in volume (at moderate pressure), down from above the top deck, by means of which a complete change of air to the extent of 9,000,000 cubic feet per hour may be effected by the expenditure of 60 H.P., with the result of the great reduction of the highly heated atmospheric temperature inside, and of the giving of a phenomenal feeling of freshness and movement to the engine room atmosphere without uncomfortable draughts.

It will be seen that any strong wind blowing into the large bell-mouth inlets on top deck naturally benefits the installation, the peripheral area of the open fan below being much greater always than the cross-sectional area of the combined downward air ducts.

An installation on the above principle is in active operation on board the great Cunarder Q.S.T.R.M.S.S. *Lusitania*, by means of which 100,000 cubic feet of fresh air per minute (in excess of what has hitherto been available) are delivered at about 1 inch velocity

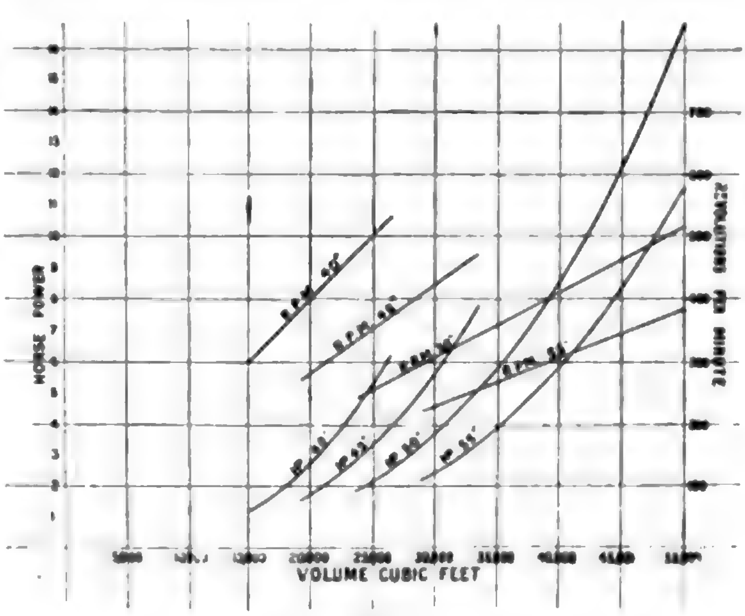



FIG. 4.

water-gauge into the central turbine engine room in manner shown. The open fan used in this case is 7 feet 6 inches in outside diameter, has a 72-inch diameter air inlet, runs at 380 revolutions per minute, and is electrically and directly driven by a 40-H.P. shunt-wound motor. The downward fresh air inlet ducts have been enlarged to give a combined cross-sectional area of 40 square feet. A complete change of air is now given in the said engine room to the extent of eighty times its air cubical contents per hour, instead of from four to five times per hour only as formerly, and the high temperature of 150 degrees Fahr., more or less, has been reduced to something nearer one-half that temperature. A somewhat similar installation, but on a larger and more complete scale, has been arranged and is at present in hand for the engine rooms of the even greater Cunarder S.S. *Aquitania*, now launched, and nearing completion on the Clyde, by means of which no less than 16,200,000 cubic feet of fresh air per hour will be delivered (100 feet down below) into the three engine rooms, or, a complete change of atmosphere in the engine rooms, to the extent of their whole air cubical contents twice every minute, will be effected. These installations were definitely decided on after a visit from the superintendent engineer of the Cunard Company to the Singer Building engine room, New York.

The principle of the arrangement and application is that the cool, fresh and heavier air over the ocean (especially in northern latitudes) is drawn down in volume from the upper deck and delivered and diffused laterally by a specially designed open fan placed as low down in the engine room as permissible, flooding the whole engine room more or less to the extent already mentioned with air at considerable velocity, but so distributed by the peculiar action of the fan as to avoid draughts, with the result that the cooler incoming air of greater specific gravity falls towards the floor and displaces or expels the heated and lighter air contents bodily up the main hatch or hatches or other exits, preferably without the necessity for extract fans at all. A similar result so far only as air volume is concerned could be obtained by blowing or forcing the same quantity of air downwards by cased fans from the top deck at practically double the water-gauge above in order to get the necessary velocity and volume below, but the expenditure in horse-power would be greater while the air distribution in engine room in such volume could only make for nothing but uncomfortable draughts. When it is considered that many of these modern underdeck (as well as underground) engine rooms have a uniform or an unvarying overheated "*windless atmosphere*" of from at least 100 degrees Fahr. in winter to 150 degrees Fahr. in summer, notwithstanding the usual apparatus in use for attempting to secure so-called mechanical ventilation, the seriousness of Dr. Leonard Hill's remarks will be better appreciated.

Reference is made to the accompanying curves (Fig. 4) showing the horse-power, revolutions, and volume of air of four sizes of open fans each having a 40, 45, 50 and 55 inches diameter air inlet respectively, and working practically under free air conditions or as described. Should it be desired to know the output for other sizes of these fans with horse-power and speed, say, for instance, for a fan having a 60 inches diameter air inlet, first, refer to the curve to see the best output for one size given; the best size to take would be the 50 inches size, viz., the one having the increased length of curve shown to give a better range. It will be seen that a good economical output for the 50 inches size would be 40,000 cubic feet per minute. A corresponding output on a 60 inches size would be proportional to the square of the diameter, and would be obtained as follows:—

$$\frac{40{,}000 \times 60^2}{50^2} = 57{,}600 \text{ cubic feet.}$$

The speed, again, will be inversely in proportion to the diameters; it

will be noted that the speed for 40,000 cubic feet on the 50 inches size fan is 410 revolutions, so that the speed for the 60 inches size will be

$$\frac{410 \times 50}{60} = 342 \text{ revolutions per minute.}$$

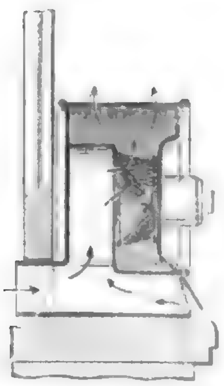


FIG. 5.

FIG. 6.

The power will be in direct proportion to the outputs, thus: the horse-power for the 50 inches size at 40,000 cubic feet will be seen from the curve to be 8.6, therefore, the horse-power for the 60 inches size will be

$$\frac{8{\cdot}6 \times 57{,}600}{40{,}000} = 12{\cdot}4 \text{ h.p.}$$

section, a transverse section, and an elevation in perspective, of the window, railway carriage,or wall apparatus.

The main feature of the new method and system is the drawing in of fresh air direct from the outside by a small size open fan either of single or double air inlet, the fan being driven by a small electrical motor, the air being propelled into the room or other enclosed place through a comparatively large area of fine wire gauze in such minute streaks or particles that good ventilation may be obtained without draught discomforts. These electrically-run ventilators are noiseless when motors only run up to 1,200 revolutions per minute, and give full volume of air for ordinary room ventilation. Where noise may be permissible in the running of motors at higher speeds (as, say, in workshops, railway carriages, etc.), over three times the amount of air may be obtained from the same size of apparatus by the use of larger motors with an increased expenditure of electrical current.

Fig. 8 is an end elevation of the ventilator, showing its application to an ordinary window, the window being placed on each side of it so fill up the gaps. When installed upon the

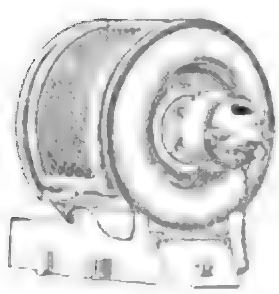


FIG. 7.

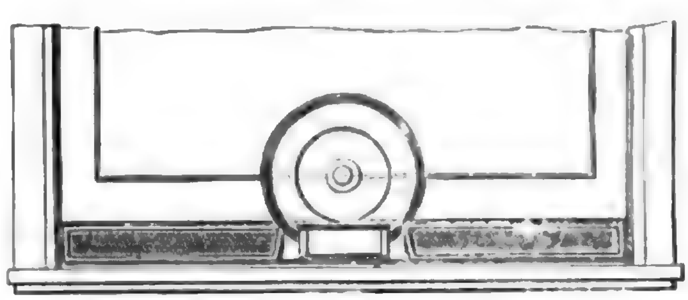


FIG. 8.

In this way the curves may be worked backwards and forwards, based on the principle that the output of the fan is proportional to the square of its diameter at equivalent peripheral speed.

4. The following diagrams illustrate different forms of new apparatus all electrically run for giving positive plenum ventilation, and are applicable to windows, columns, railway carriages, etc.

Figs. 5, 6 and 7, in their order represent respectively a longitudinal

window-sill of an office in the manner indicated, the ventilator will give without noise over 6,500 cubic feet of fresh "live" air every hour, without discomfort from draught. This application requires but 24 watts, or .8 carbon 8-candle-power incandescent electric lamp current for its operation; the motor running not more than 1,200 revolutions per minute. Thus, in a room, say 18 feet in length by 16 feet in width and 11 feet in height with an open fireplace or chimney exit,

with two windows, and having one of these plenum units installed in each window, a complete change of air would be effected to the extent of 13,000 cubic feet per hour, or over four times the whole cubical air contents of the room every hour at an expenditure of electric current equivalent to 1·6 carbon 8-candle-power incandescent electric lamp, or 48 watts. The window ventilator may also be provided with a fine gauze rain-proof screen or filter on the air inlet, outside, for the screening of the air of dust or flies, etc., before it enters the apparatus.

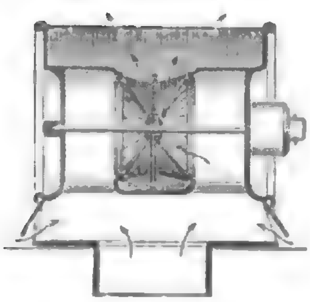


FIG. 9.

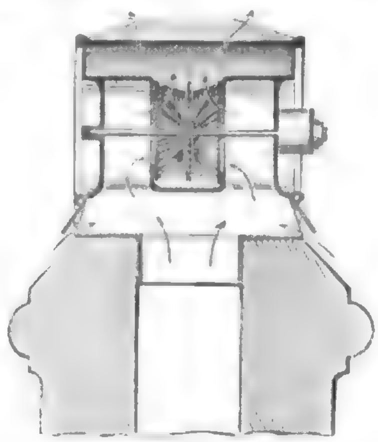


FIG. 10.

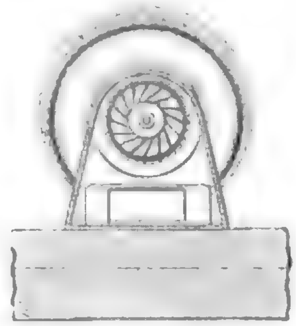


FIG. 11.

Figs. 9, 10 and 11 represent respectively a longitudinal vertical section, a similar section with fog filter, and a transverse section of a column or double-fan inlet plenum ventilator, for placing on top of a column for giving increased ventilation on the same lines. When the ventilators are fitted with fog filters or absorbing covers, as shown in section of column ventilator by Figs. 10 and 11, pure filtered air in more or less volume, absolutely free from fog or other deleterious matter, may be poured into any apartment all the time free from draught and impurity discomforts, according to the power and speed of the electrical motor provided. The column plenum, ventilator, as shown by Fig. 9, will give without noise over 18,000 cubic feet of air every hour without draughts. Two of these column plenum ventilators have for some time been installed in the Masonic Temple, Queen's Hotel, Manchester, and they are doing full duty without noise.

By the application of the new system to railway carriages, cabins, and state rooms, the whole cubical air contents of even the largest railway carriages, or compartments on board ship, may be replaced by pure, fresh air from the outside to the extent of from five to ten times or more per hour; or, by the use of several of these apparati, a crowded room or hall may be supplied with the maximum ventilation required per hour per head, entirely free from any draught discomforts.

5. Up to this point the writer has dealt solely with the cooling and freshening of the atmosphere in overheated engine rooms and other apartments by new methods, all as advocated by Dr. Leonard Hill on the score of health. Under certain circumstances, however, it is often necessary to furnish fresh air in volume, either artificially cooled or warmed. Fig. 12 represents an example of an electrically-run open fan installation, having an 80-inch diameter air inlet at the floor level, and an external diameter of 90 inches maximum at the fan, surmounting a steel column 8 feet in diameter and 14 feet in height, the installation being capable of handling quietly 80,000 cubic feet of cooled or warmed air per minute, 60,000 cubic feet of that being fresh air, and 20,000 cubic feet of it being inside air in circulation.

Within the large cylindrical steel column, cooling or heating elements, to the extent of 1,500 square feet, may be arranged, to give the desired temperature to the air coming from

outside and propelled into the hall or other large apartment in which the column may be placed; while the atmosphere of the said hall or apartment, in which the column stands, may be circulated at pleasure up through the movable registers "A," in order to keep the whole air of the apartment in movement even at the floor level.

"In ventilation, like other things, it

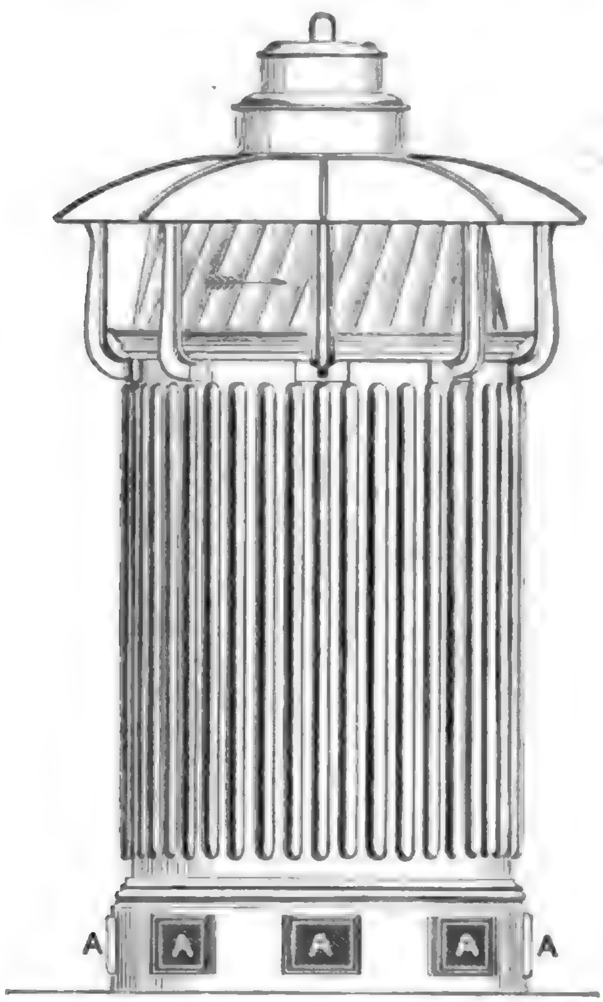



FIG. 12.—Scale: 3-16 inch = 1 foot, or, about one-sixtieth actual size.

is the realities that matter; and, although according to theory or rudimental principles it would appear to be equally efficient to force air down or through a properly proportioned and constructed duct or conduit of any given length as it is to draw air down or through the same, in the experience of the writer (especially under such unnatural conditions as pertain in deep stokeholds of great liners) this does not always appear to be quite the case in actual practice, unless with the addition of special and large delivery or distributing diffusers at the lower ends of the air ducts in order to secure the full value in increased volume of air at a lower velocity for the additional power expended in the first instance."

Another example may with advantage be given of an arrangement for cooling or warming (preferably for warming) fresh air in volume.

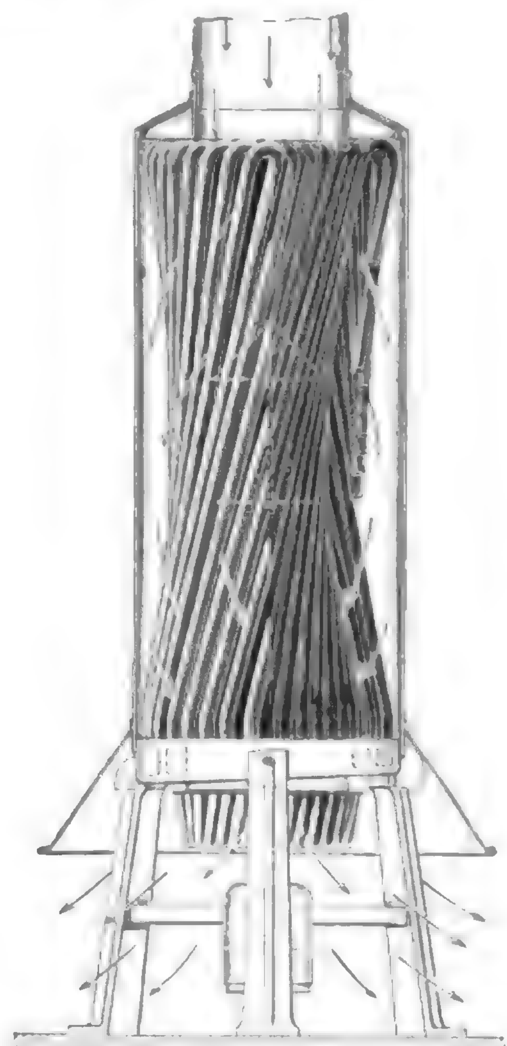


FIG. 13.

Fig. 13 represents on a reduced scale a part vertical section and a part elevation of an open fan installation, electrically run, for delivering either artificially cooled or warmed air into an apartment or enclosed space.

If for warming purposes the air would preferably be delivered at the floor level, this can be done, one of the main features of this arrangement being that not only would the air be most efficiently treated, but its

distribution would be equally good. As seen by the diagram, the apparatus at its lower part is shown as resting on the floor, but naturally it may also be constructed for fixing at a higher level, according to circumstances and the intention. In this case the whole may be connected to a fresh air duct coming down through the roof or from the upper portion of a building, which makes the arrangement somewhat different from that shown by Fig. 12.

Figs. 14, 15 and 16 again represent respectively an elevation, a transverse section, and a longitudinal section, of what might be called a " Rhigothermo " (or cold or heat) ventilating cased fan installation—electrically run—for effectively delivering under moderate pressure an abundant supply of fresh, cooled, diluted, or warmed air from the upper deck of a modern ocean liner or war vessel, down to the various state rooms, cabins, etc., below.

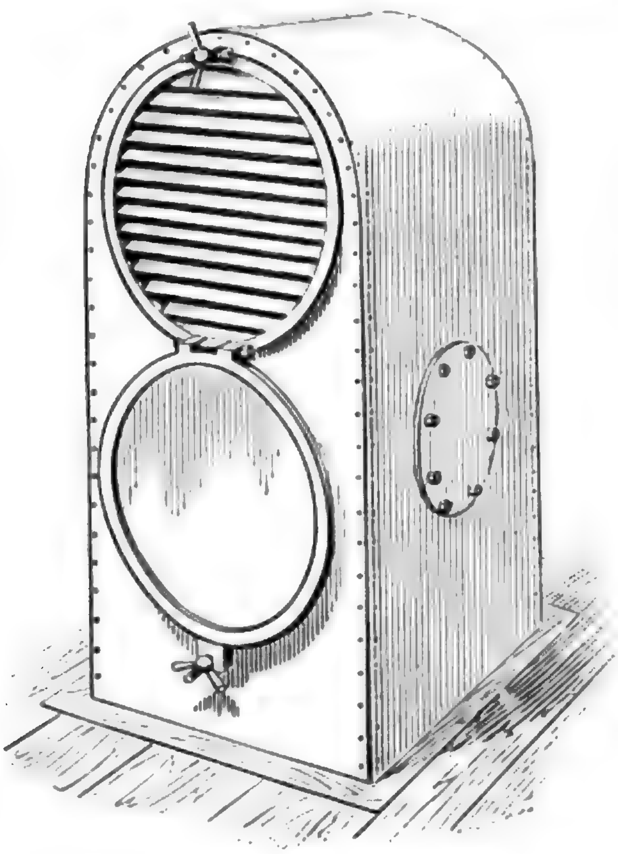


FIG. 14.

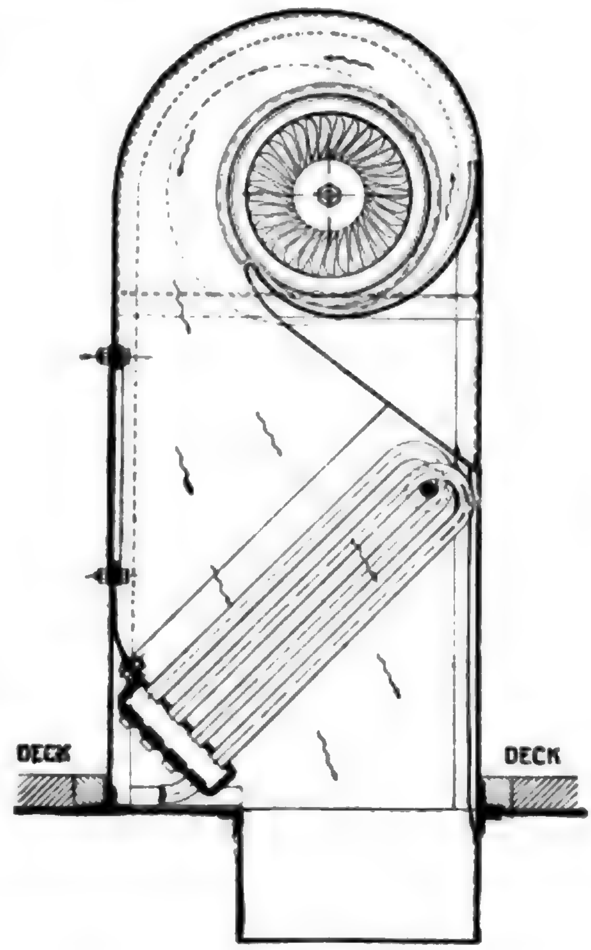



FIG. 15.

When it is stated that with, say, a difference of temperature of 40 degrees Fahr. between the temperature of the outside air in cold weather and that of the air delivered into the deck duct, every 1,000 cubic feet of air per minute so delivered at a constant 2 inches total water-gauge pressure only requires in motor electrical current the expenditure of about ½ h.p., it will be seen that by this means the very highest possible efficiency is obtainable. So far as the writer knows this special application is distinctly novel, and is quite different in principle and action from the usual method of forcing air by a fan at a much higher initial pressure through small tubes in a cylinder taking infinitely more power, and by which there is a great loss of air in volume before it is ultimately delivered at the lower pressure necessary. By the newer method and as illustrated, the fan draws in the fresh air and propels it downwards and freely around heated or cooled surfaces, and compresses it only to the delivery pressure necessary for the main duct; thus a most material increase in air volume and saving

in power is effected, there being actually no loss in air volume between the fan outlet and the inlet to main air duct going through deck.

Until very lately, it was not possible to obtain open fans capable of creating

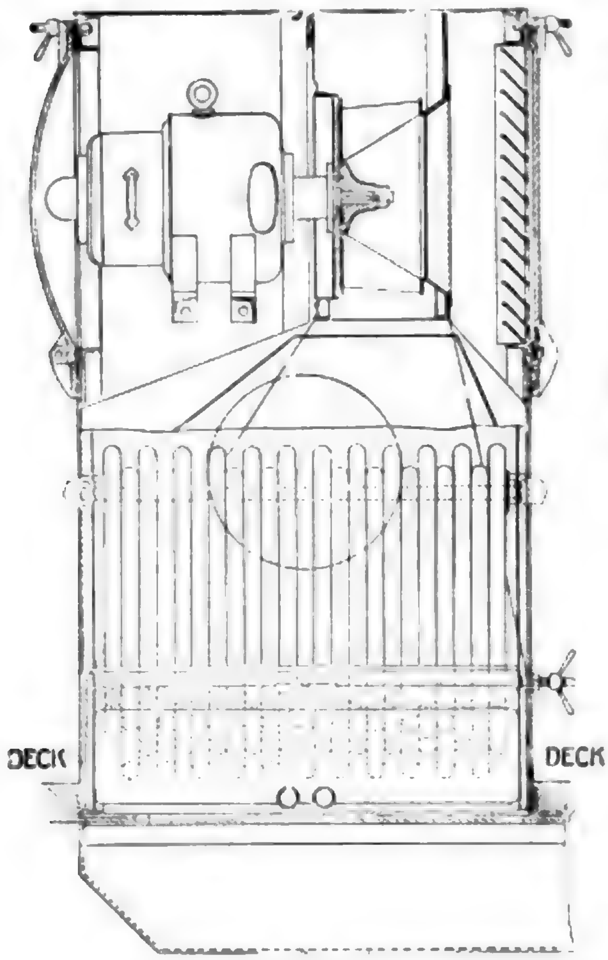



FIG. 16.

a water-gauge to any extent in a duct or air-inlet and of handling air so obtained and delivering it in volume into open space at a fairly high velocity; but now, such open fans may be obtained capable of effectively performing such work even if and when necessary against a *static* pressure on the delivery side, and that, too, without backslip, as has already been stated, and as the examples following may show.

Fig. 17 represents one of these new types of open fans (direct electrically-driven), capable of giving a large volume of air with a moderate pressure of from 1 inch to $1\frac{1}{2}$ inch, or as much as up to 2 inches water-gauge.

Figs. 18 and 19 again represent the application of the new method of ventilation to a general shipping or other public office for the purpose of freshening up the atmosphere and keeping it pure, sweet, comfortable and equable in temperature at all times of the year.

By means of this installation a flow of fresh air in volume of approximately 3,000 cubic feet per minute in cold weather and 5,000 cubic feet per minute in summer without appreciable cold draughts, or, respectively, a complete change of the whole cubical

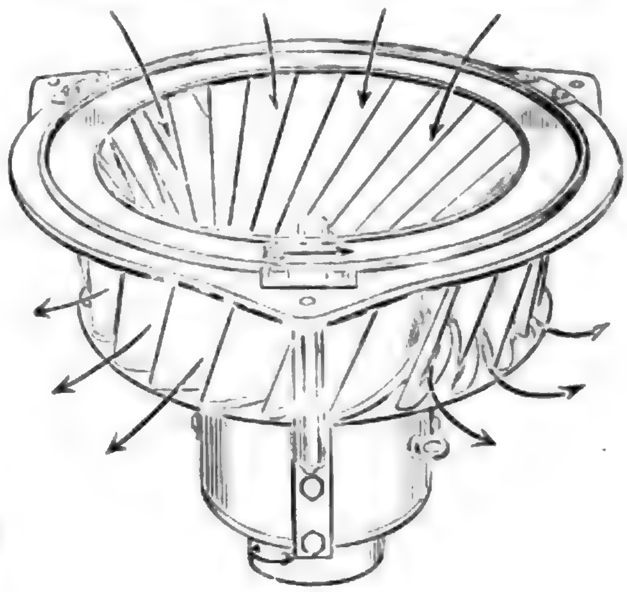


FIG. 17.

air contents of the office to the extent of sixteen times an hour in winter and twenty-seven times an hour in summer, may be obtainable at an expenditure of electrical current for the motor of only about from $\frac{3}{8}$ h.p. in winter to $\frac{1}{4}$ h.p. in summer. The fresh air—taken from at least 12 feet above the street level—by the noiseless-running electrically-driven open fan (having a 25 inches diameter air inlet and running at from 280 minimum to 460 maximum revolutions per minute) would thus be delivered horizontally between the two steel discs, either warmed or cold, along the ceiling of the office at from 9 to 10 feet from the floor level, and then would gradually fall towards the two fireplaces, tending to increase the better draught of the chimneys. From the disc above the fan a cotton or other fringe would hang (as shown by dotted lines at "A"—"A") which, being

flexible from the lower edge, would indicate visibly and effectively the constant movement of the air handled, and would assist the imagination of

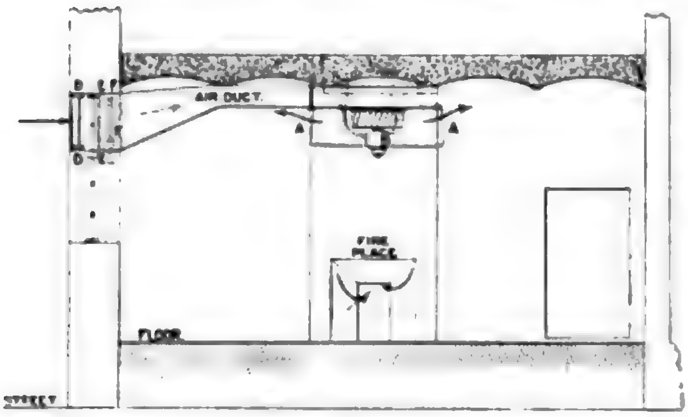



FIG. 18.—TRANSVERSE SECTION OF OFFICE, AND LONGITUDINAL SECTION THROUGH FRESH AIR DUCT.
Cross Section (between "D" and "D") through fine brass gauze screens in frames removable from the outside.
Cross Section (between "E" and "E"), through adjustable Louvres.
End Elevation ("F" and "F") of vertical pipe long steam Radiator.
Hanging fringe ("A"—"A") round Disc Plates.

sensitive inmates that a constant change of air was being effected without any felt draughts.

This new type of open fan (strengthened) as shown in Fig. 20 has been called for by the British and United States Naval Authorities for placing in the latest torpedo-boat destroyers, and has been specially constructed

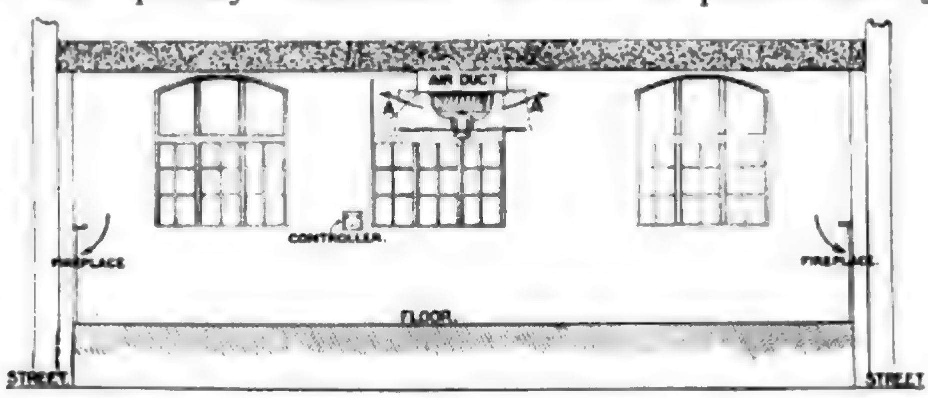



FIG. 19.—LONGITUDINAL SECTION THROUGH OFFICE, AND TRANSVERSE SECTION THROUGH FRESH AIR DUCT.

for being directly driven by high-speed steam turbines to give large volumes of air against a high water-gauge with a combined efficiency. These open fans have been satisfactorily installed in the "Terry," "Chauncey," and other United States Government torpedo boat destroyers, and are also being supplied to the latest British destroyers. The open fans with air-inlets up to 30 inches diameter are capable of being safely run on test up to 2,000 revolutions per minute, and have been so run on official test in London, in Washington, and on the Clyde, while in practice they are being run on the "Terry," "Chauncey," etc., at 1,600 revolutions per minute, each delivering 20,000 cubic feet of air per minute against a *static* water-gauge of 5 inches in the stokeholds.

Diagram 21 represents test curves made at Hartford, Conn., United States, by the Terry Steam Turbine Company, in presence of Mr. W. Carlile Wallace, C.E., Assoc. M.Inst.C.E., M.Inst.N.A., Eng., with open type fan (as per Fig. 20), having 25 inches diameter air inlet, directly driven by a Terry Steam Turbine, in order to ascertain the combined efficiency of the said Open Fan and Steam Turbine.

The curves (Fig. 22) show the volume and efficiency and volume and speed at 1 inch *static* water-gauge when the fan was exhausting from a 35-inch diameter tube. This test was taken on one of the open fans for the Terry Turbine Company, Hartford, Connecticut.

By these two curves it is possible to arrive at the power taken by the fan and the speed at which it should run for any duty within its range. To do this it is necessary first to divide the volume required by the square root of the water-gauge required. This will give the point on the base line from which to work, as by noting the corresponding points on the two curves, the efficiency and speed can be

obtained. This speed will require multiplying by the square root of the water-gauge required, and from the efficiency the power can be obtained by working out the horse-power in the air, and dividing by the efficiency.

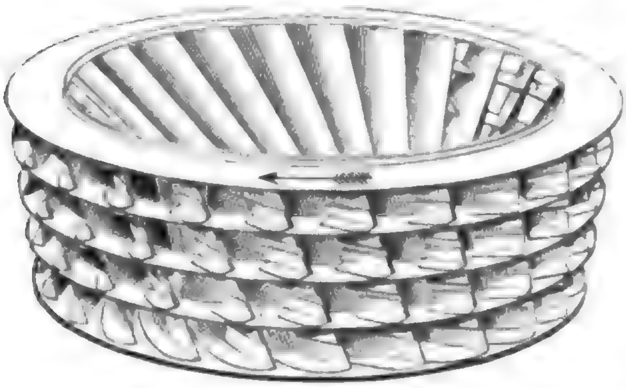


FIG. 20.

The following formulæ will give the horse-power in the air :—

$$\text{H.P in air} = \frac{\text{Cub. ft. per min.} \times \text{W.G.} \times 5{\cdot}2}{33{,}000}$$

This divided by the efficiency will give the horse-power required or, simplified :—

$$\text{H.P. required} = \frac{\text{Cub. ft. per min.} \times \text{W.G.}}{63{\cdot}5 \times \text{Efficiency \%}}$$

It may be noted that one great advantage of these methods of ventilation is, that, given a pure source from which to obtain the fresh air supply, all local or surrounding smells or contaminations are effectually kept out of the apartments or places treated, while with an ample volume of fresh air injected, the vitiated air is thoroughly displaced and expelled through the proper exits provided.

It goes without saying that where the external source may be suspicious or where the air supply may be dust-laden or smoke-contaminated, the said air supply may require to be screened and cleansed before it may be propelled into buildings containing valuable and delicate machinery or stock and where there may be many human workers.

In the case of the Singer Building (Example 1), for instance, the only sources available were the side-walk of Liberty Street on the one side, and the open area between the wings of the building block, from which the fresh air for the fans' supply is drawn into large chambers through considerable areas of damp berlap before it passes into the inlet conduits and is delivered by the fans into the engine room.

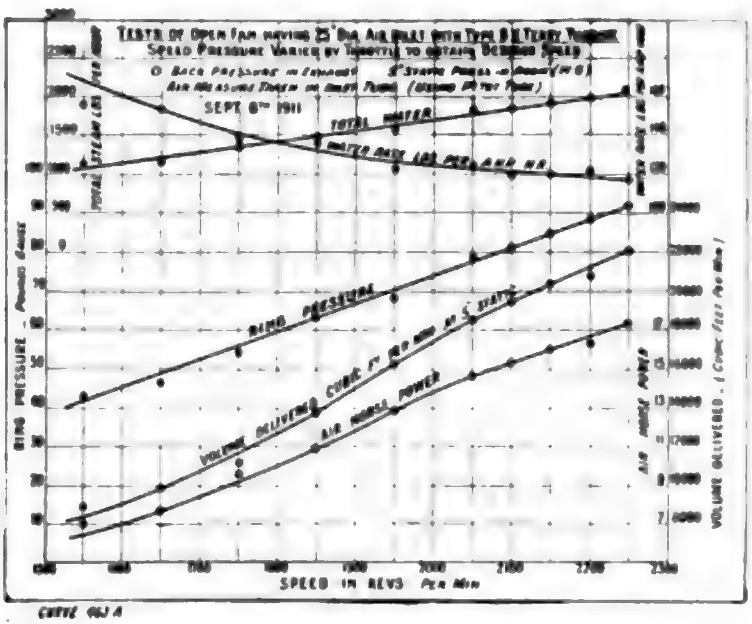



FIG. 21.—BOX TEST AT WORKS, HARTFORD, CONN., U.S.A.

Although, as Dr. Leonard Hill has well said, the open fire and wide chimney ensure ventilation, those only apply to comparatively small rooms when not crowded, and in the United Kingdom which is the only country where open fires are really in

general use: what the doctor has called a sufficient draught of cool and relatively dry air—conducive to good health—in crowded places, and especially in overheated engine rooms and such like, can only be effectively and comfortably obtained by methods similar to those described and illustrated.

Of course, beyond certain limits it may not be advisable nor permissible to propel immense volumes of very cold air into all kinds of buildings, but in the opinion and experience of the writer, the limit—even when completely changing the cubical contents of air 120 times an hour has not yet been reached in the case of what might be called a "torrid" or "tropical" engine room, stoke-hold, or workshop having an atmosphere so sultry as may be approaching 150 degrees Fahr. more or less; and, from practical experiments, he is convinced that under such circumstances a change of atmosphere to almost any reasonable extent is quite practicable by the new method advocated and as shown in Examples 1, 2, 3, and 5, without causing any discomfort from draughts.

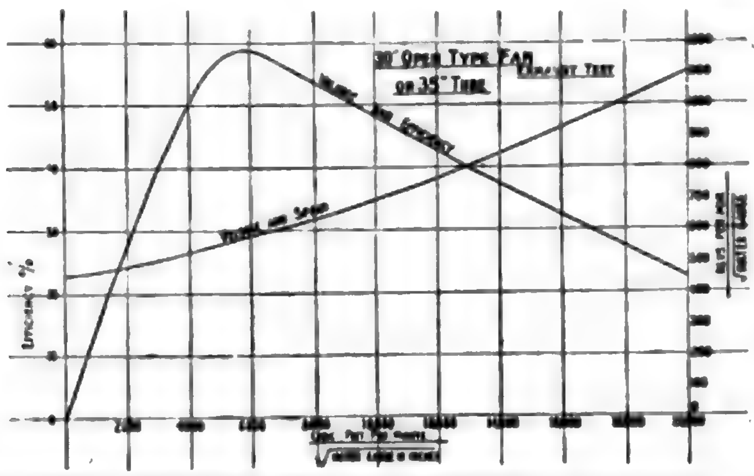


FIG. 22.—CURVES SHOWING THE VOLUME AND EFFICIENCY OF OPEN TYPE FAN.

During recent years many salutary laws have been passed by Parliament for the better ventilation of factories for certain industries, mines, and workshops in particular unhealthy trades, but, as may be seen from the published death records pertaining to other particular trades and districts, it is evident that much more requires to be done in the securing of adequate light and air space, fresh air, and coolness in overcrowded and underground enclosures.

# THE ROYAL AGRICULTURAL SOCIETY'S SHOW AT BRISTOL

SOME OF THE ENGINEERING EXHIBITS

By A Correspondent

If one were asked to state briefly the most noticeable features on the engineering side of the "Royal" show of this and recent years, it would not be far from the mark to say that they are to be seen in the steady and remarkable progress of the internal combustion engine in its various applications to farm work, and its encroachment upon the domain of the steam engine; the rise of the light tractor and self-propelled wagon in connection with the cheap transport problem, and generally in the increased and increasing uses of mechanical appliances in connection with farm, or, to put it more broadly, agricultural work.

It is true that at these shows we find a good many exhibits which it would require a considerable exercise of imagination to connect directly with farm work, for instance, boat propelling machinery, and high power engines of 60 to as much as 150 H.P., but on the other hand there is no lack of examples which clearly illustrate the points mentioned.

It is only a very few years since the first introduction of the petrol and paraffin engine, the self-propelled wagon, and still more recently, the tractor system of ploughing in a commercially successful way. At first all these were looked upon as curiosities, by many they were scoffed at, but to-day they are not only recognised and accepted, but they are proving the possibility of doing things in a commercially economical way that had previously been deemed impossible.

When a firm like Fowler's, of Leeds, exhibit, as they have done this year, not only an internal combustion traction engine, but also a small single or double furrow plough worked by a petrol motor, it brings home to us the extent of the revolution, for it can be called nothing less, through which we are passing.

One of the remarkable incidents of the situation is the effect upon the steam engine. Just as, years ago, the introduction of electric lighting for domestic purposes led to immediate and far-reaching improvements in gas lighting, which enabled the latter to hold its own, and even more than hold its own with its formidable competitor, so we find that the steam engineers, stimulated by the internal combustion invader, have set their wits to work to improve the steam engine, so that it also may be able to hold its own.

The result is seen in the adoption of higher boiler pressures, the use of superheaters and feed water heaters, more care in protection of heat radiating surfaces, and in design throughout. So, the steam engine is not dead yet by any means, but, notwithstanding all the improvements, it is still heavily handicapped in the matter of the carriage of its fuel and water supply, and because it is so much less convenient and compact in regard to the space it occupies. It would be impossible in the space at our disposal even to name the exhibits at the Royal Show, but in the following pages will be found descriptions and illustrations of a small selection, given in alphabetical order of the names of the exhibiting firms:—

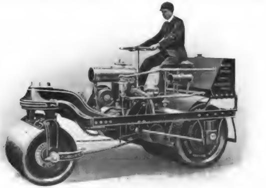
ALLEY & MACLELLAN, LTD., Glasgow.—" The Sentinel " steam wagons built by this firm enjoy a reputation which could only be due to their good and consistent work on the road. Two types are made, viz., an " under-

type," in which the engine is placed underneath the main frame, and an "overhead" type, in which the engine is placed on top.

WAGON WITH HYDRAULIC TIPPER, BY ALLEY AND MACLELLAN LTD. OF GLASGOW

Our illustration shows one of the former fitted with an end tipping body. The special features embody so many points of interest that it is impossible even to specify them here, but it may be said briefly that they comprise a vertical multitubular boiler, an all-enclosed double cylinder engine fitted with long pistons, and poppet valves, and central pivot steering. The boiler is of the water-tube variety and is so designed that the firebox and tubes can be dropped for cleaning. A superheater of solid drawn steel tubing is fitted in the smoke box, the design of the engine being such as to permit of the use of superheated steam with marked advantage. The working steam pressure is 230 lbs. per sq. inch.

The tipping mechanism of this wagon deserves attention from its compactness, simplicity, and the ease and rapidity with which it operates.



MOTOR ROAD ROLLER, MANUFACTURED BY MESSRS. BARFORD & PERKINS LTD., PETERBOROUGH.

It consists of an hydraulic cylinder suspended by trunion brackets to the main frame and fitted with a ram whose top end is attached to the under side of the box body. Water

is supplied by a steam pump capable of producing a pressure of 400 lbs. per sq. inch, which is also arranged for use as an alternative boiler feed, and the operation of discharging the load and returning the body to its normal position occupies only three minutes.

Standard "Sentinel" wagons are of six tons capacity, but they will haul an additional four tons on a trailer.

Barford and Perkins, Ltd., Peterborough.—The patent water ballast motor road rollers, of which we believe this firm were the original pioneers, have, like many others of the offspring of the petrol motor, proved their value, and firmly established themselves in public estimation in a period of time so short as to be more like romance than reality. It is hard to realise that the first of these machines offered was exhibited and sold only eight years ago, and, moreover, it speaks well for the soundness of its design and construction when it is stated that it has been in regular use during these eight years, and is so still. The exhibit of rollers by Messrs. Barford and Perkins, at the Bristol Show, embraced four different sizes, from 11 tons down to about 30 cwt., the last-named being specially useful for agricultural purposes, as also for golf clubs, racecourses, cricket grounds, and so on. Beginning at first with petrol motors, the firm, after a course of careful experiments and severe tests, produced one suitable for using paraffin fuel, and these, since their introduction, have proved quite successful. Although the roller, of which we give an illustration, has not altered much in general appearance since its first introduction, alterations and improvements have been made from time to time, as experience has indicated their necessity. The engine and driving gear have received special attention, with a view to making every part simple and strong. To the front head has been fitted a patented spring device, with the object of reducing vibration and giving the advantages of a spring drive; the diameter of the front rollers, also, has been increased. For foreign countries these motor rollers have proved markedly successful, independence of coal and water permitting of their use in situations where steam would be impossible. They have also found an extensive field in the making of tarmacadam roads, for which a machine of 5 to 8 tons is most suitable.

The Campbell Gas Engine Co., Ltd., Halifax.—From amongst the large range of gas and oil engines on this firm's stand we have selected one of their high compression crude oil type for description. As is necessary in an engine of the kind, the construction is on particularly heavy and massive lines. It operates on the well-known "Otto" or four-stroke cycle, and the fuel is injected into the vaporiser through a special form of atomiser. As the point of fuel injection is only at the end of the compression stroke, any tendency towards pre-ignition or backfiring is eliminated. For starting up, a heating lamp is used for a few minutes, but once the engine is running this is not required, as the heat maintained in the vaporiser is sufficient to ignite the charge automatically. It is claimed that this engine will use practically any kind of crude oil so long as it will pass through a half-inch pipe, and as—notwithstanding the high compression—there is no water injection, or complications of that kind, the working parts are commendably few and simple. Special attention has been given to the question of lubrication, the arrangements for which are of the most complete and efficient kind, including pump forced feed to cylinder and piston, automatic ring oilers for crank and camshafts, and centrifugal type, with sight feed, to connecting rod big end. This type of engine has proved remarkably efficient, and experience has shown that the actual brake power developed on test, is well over the figures specified in the firm's lists. The Campbell Engine Co.'s long experience in the manufacture of gas and oil engine extends over a long period of years, and it has stood them in good stead in enabling them to attain high rates of economy and efficiency, combined with good practical design.

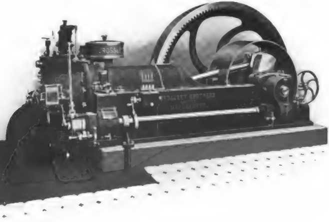
Clayton and Shuttleworth, Ltd. Lincoln.—Our illustration represents one of this firm's 3-ton standard steam

wagons, which is of the "overhead" type, the final drive to rear wheels being by roller chain. The boiler is of the "Belpaire" loco type, which has been found entirely successful for all their self-propelled engines; the working pressure is 200 lbs. per sq. inch. The engine is compound and carefully balanced, and particular care has been taken to have a quite silent exhaust. At normal engine speed this wagon travels on the road at 3 or 6 miles per hour, as required. All the gears are cut from special steel, including the differential, which latter runs in an oil-tight casing. Road wheels are very strong and wide, built of steel with C.I. hubs, and faced with wide hard steel diagonal strips. For certain kinds of working conditions rubber tyred wheels can be fitted.


3-TON STEAM WAGON SHOWN BY MESSRS. CLAYTON & SHUTTLEWORTH, LTD., OF LINCOLN.

Crossley Brothers, Ltd., Manchester.—To those interested in gas and heavy oil engines the Crossley stand is always a centre of attraction; and, as might have been expected, the firm's fine display at Bristol was fully up to their usual high standard. They showed five of their latest type engines, ranging in size from 8 H.P. to 70 H.P., working on town's gas, suction gas, and oil, together with—and for the first time — one of their new open-hearth patent gas plants.

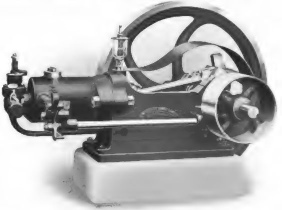
The leading features of the Crossley engines are, massive construction; with cylinders supported for their entire length, and all valves arranged vertically; a simple and symmetrical form of combustion chamber in one casting; no unwatered valve covers, and no bolts or fixing studs situated in the water spaces where they would be subject to corrosion; a complete and efficient—and adjustable—system of lubrication; good governing, and, in general, scientific design and con-



NEW OIL ENGINE BY MESSRS. CROSSLEY BROS., LTD., OF MANCHESTER.

struction throughout, combined with the highest class of material and workmanship. The accompanying illustration shows one of their new engines in which the symmetrical and simple disposition of the parts will be noticed.

Another interesting exhibit was one of their horizontal semi-Diesel engines, designed to overcome certain difficulties commonly experienced with the usual closed hearth type, in which, when using the poorer or smaller grades of anthracite or coke, there is a tendency for the fuel to adhere to the sides of the firebrick lining, and also for clinker and ash to choke the fire grates.

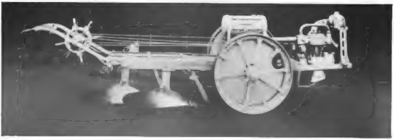


ANOTHER OIL ENGINE SUITABLE FOR FARM USE EXHIBITED BY MESSRS. CROSSLEY BROS., LTD.

suitable for using almost any kind of crude oil or distillates. These engines are built in sizes up to 100 B.H.P., using moderate compressions. Injection of the fuel is effected by means of a powerful pump.

The new patent suction gas plant which, as already remarked, was exhibited for the first time, has been

In the new Crossley plant these objections have been entirely eliminated, by providing a series of poke holes on top of the generator, through which a poker may be used to detach any clinker that may adhere to the lining, the holes being so situated that the poker works in a line parallel with and immediately adjacent to the



PATENT MOTOR PLOUGH SHOWN BY MESSRS. J. FOWLER & CO., LTD., OF LEEDS.

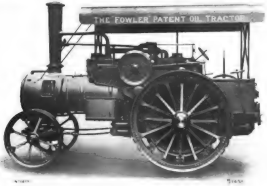
brickwork and so that every part of the lining is accessible. There are many other details which might be noticed did space permit. It must suffice here to say that the plant embodies every improvement suggested by past experience, and is said to realise in practice the advantages expected of it.

Our smaller illustration shows what Messrs. Crossley term "the simplest oil engine made," and certainly its appearance does not belie the description. It is made in sizes from $1\frac{1}{2}$ to 5 B.H.P., and is designed to use paraffin, and by persons who may have little or no knowledge of engines, to whom, therefore, simplicity is of particular moment. As there is only one cam and lever in the valve gear there is not much chance of anything going wrong, nor is there much to keep clean, so it would be difficult to imagine anything more suitable for farm work.

John Fowler and Co. (Leeds), Ltd., Leeds.—In addition to their usual fine display of compound steam ploughing engines and implements suitable for their well tried double engine system, heavy road locomotives and general purpose traction engines, there were two items on their stand which attracted well-deserved attention; we refer to their patent 50 B.H.P. "road locomotive type" oil tractor, and the Fowler-Wyles patent motor plough, both of which we illustrate.

The oil tractor, which weighs in working order about 9 tons, is designed, as will be noticed, on traction engine lines, and it differs from those usually made, in that the engine is horizontal and is mounted on top of a frame resembling a locomotive steam boiler, the side plates of the firebox being extended to carry the engine, whilst the barrel forms a fuel reservoir with a capacity for three days working. The gearing is enclosed in the space usually occupied by the firebox and is thus completely protected from dust. A centrally positioned winding-forward drum is fitted which pulls the load direct up to the coupling point of the draw bar instead of to the side as is usually the case. The power is transmitted through a friction clutch, and gearing—with change speed pinions operated by levers from the footplate—to rings of gear with internal teeth secured to the hind wheel rims. The engine is spring mounted, back and front, and every detail has been most carefully considered and fully proved on the road.

The Fowler-Wyles motor plough is quite a new departure. It has been designed to meet the demand for a small self contained motor plough capable of doing general farm work




J. FOWLER & CO.'S 50 B.H.P. INTERNAL COMBUSTION TRACTION ENGINE.

such as is usually done by horses, and specially suitable for use in narrow strips as in orchards, vineyards, hop gardens and the like. Using paraffin fuel, this machine has been proved capable of doing twice as much ploughing as a team of horses and at about half the cost per acre. Either single or double furrow ploughs may be used, and the shares can be set to cut any width or depth of furrow within the power of the engine. The engine is single cylinder, and special attention has been paid to ensure efficient cooling, which will be found ample for any climate. The driving wheels are capable of independent vertical adjustment, while in motion; the right hand wheel being designed to run in the furrow and so making the machine self-steering. Balancing, as it does, on the driving wheels, the machine can be turned at the headlands with a minimum of effort. Automatic lubrication is provided throughout, and the designers have kept prominently in view strength of construction and simplicity of working, in regard to both of which points the unrivalled experience of the firm places them in an unique position.

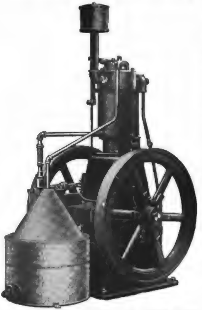
THOMAS GREEN AND SON, LTD., LEEDS.—The motor street sweeper, which we illustrate, is one of the latest productions of this firm, and embodies the results of experience gained during the past three years, during which they have made a considerable number of these machines. We understand that many large municipalities are now using them, and finding them most satisfactory and efficient. They are fitted with motors suitable for either paraffin or petrol, and this latest type is provided with a new design of gear-box which gives three speeds of 4, 7 and 11 miles per hour respectively. The question of accessibility has been carefully studied, and the brush drive and gear being placed at the back and well away from the engine and gear-box, the latter are easy to get at. A special feature is the arrangement by which the brush-raising lever can be so adjusted as to give just the necessary pressure of the brush on the road.

MOTOR ROAD SWEEPER EXHIBITED BY THOS. GREEN & SON, LTD., OF LEEDS.

Messrs. Green and Co. exhibited also a neat 5-ton motor road roller. These they now make in several sizes, most of which can be arranged on the water ballast system.

THE INTERNATIONAL HARVESTER CO., LONDON.—A good, plain, simple and serviceable looking type of vertical petrol engine is marketed by this company, the general features of which are shown by the accompanying photo. Horizontal engines are also made, but in working details they are very similar, so a description of one type will suffice. The engine is one of the class in which the cylinder head—which contains the inlet and exhaust valves—is made in a separate piece which can be easily detached at any time for examination and cleaning: cooling water is circulated through the jacket space by a small pump from a supply tank, which is clearly seen in the illustration. This tank has a cone-shaped cover of coarse mesh galvanized wire, and the return hot water is caused to trickle

over this, so that it is efficiently cooled. There are two flywheels and a driving belt pulley. Built on to one of the flywheels is a centrifugal type governor which controls engine speed effectively



THE INTERNATIONAL HARVESTER CO.'S FARMER'S ENGINE.

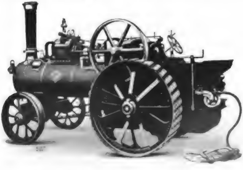
by a hit and miss arrangement acting on the exhaust valve, this latter being held open for light load, and thus preventing the automatic inlet valve from functioning. In operation this arrangement works very satisfactorily, showing good control on large and sudden load variations. For chaff cutting, churning, gristing, pulping, and various other kinds of farm work, this type of engine is admirably suited, and may be handled by quite inexperienced workmen.

IVEL AGRICULTURAL MOTORS, LTD., BIGGLESWADE.—The two small illustrations indicate very clearly the changed methods in ploughing by a mechanical tractor as compared with the old style in which horses were employed. The Ivel Company was one of the pioneer firms in this line of work, and the series of medals won by them, from the year 1904 to the present date, is eloquent proof of the success they have achieved. The Ivel tractor is fitted with 24 h.p. double cylinder horizontal engine designed to use petrol, paraffin or alcohol. The drive from the engine is transmitted through a friction clutch, and thence by chain to the rear axle. There is only one forward speed and a reverse for road or haulage work, a belt pulley on the end of the crankshaft extension being provided for stationary work, such as threshing, chaffcutting, etc. The weight of the complete machine is only 37 cwt., and as this is distributed over three wide road wheels it makes little or no impression on the land. It is unlike most of its competitors in having only a single steering wheel, but this has been found quite satisfactory, probably because the road speed is not excessive.

Ivel motors are now in use all over the world and have amply proved their economy in working and wide range of usefulness to the farmer.

THE OLD AND THE NEW WAY.
On the left, one furrow and three horses; on the right one motor and three furrows. Motor by the Ivel Motor Co.

MARSHALL, SONS AND CO., GAINSBOROUGH.—As from the extent of this exhibit it is impossible to describe much of it, we will select and deal with one or two items which were of particular interest. The traction engine, shown in the illustration, has been specially designed with a view to combining great tractive power with light weight and economy in working costs.



NEW TRACTION ENGINE, SHOWN BY MESSRS. MARSHALL SONS & CO., LTD., OF GAINSBOROUGH.

To begin with, a comparatively high working pressure has been adopted of 180 lbs. per sq. inch. The cylinder, mounted on a planed steel fixing, has lagging of extra thickness, as also has the boiler, and in order to secure the best economy in working a tubular superheater and a feed water heater, have been fitted. A fire-box with the Marshall patent cambered top, "Pickering" type high speed governor and mechanical forced feed lubrication to cylinder are also features of the design. Bearings of crankshaft, intermediate shafts and hind axle are of the automatic continuously oiled type, and the fast and slow speed gears, with cut teeth, are arranged inside the horn plates, sliding on a square shaft. The differential gear is on the firm's four pinion system, and is provided with an automatic spring locking pin. An improved winding-forward drum is fitted which has four haulage speeds and a large swivelling guide pulley for the wire rope; this latter is clearly visible in the photo. A series of severe and exhaustive trials made with this engine showed that it effected a saving of 14 per cent. on coal and 12 per cent. on water when compared with a similar engine without superheater, and no less than 34 per cent. on coal and 22 per cent. on water when compared with a single cylinder engine of the ordinary type.

The chief features of the portable engine, which is designated as "Class S.P.," are found in the high boiler pressure of 10 atmospheres, the patent superheater, and automatic governing in connection with a crankshaft governor and balanced piston valve. The patent cambered top fire-box, which entirely dispenses with roof stays, is incorporated in this boiler, heating surface has been increased, and the lagging is of special quality and thickness to prevent loss of heat by radiation. This, by the way, is a point deserving of much greater attention than it receives, the loss in fuel due to heat radiation being more important than most people seem to think.

To return to the portable engine, our description may be concluded by saying that the superheater consists of a series of solid drawn steel tubes contained in the extended smoke-box, so arranged as not to interfere with the cleaning of the boiler tubes. A feed-water heater, utilizing exhaust steam, is also fitted. We understand that these improved portables are giving an excellent account of themselves.

MERRYWEATHER AND SONS, LONDON.—The name of Merryweather at once

brings to mind fire engines and fire appliances of every kind, in the manufacture of which they have for so many years been engaged. Incidentally it was not surprising to hear that the fire protection arrangements in connection with the show had been entrusted to their care, and thanks to the perfection of the precautionary measures taken, a small fire which broke out very early one morning amongst the horse boxes was dealt with within five minutes of the time the summons was received, and the men were back at their stations, after suppressing the outbreak, within half an hour. On this stand were to be found a most comprehensive display of fire-fighting appliances of all kinds.

Messrs. Merryweather do not, however, confine themselves to the manufacture of fire appliances, though that is the main part of their business; for years they have specialised in water supply arrangements for country mansions, and more recently they have devoted a considerable amount of attention to steam and petrol driven pumps for fruit spraying and irrigation work.

The accompanying illustration shows one of their "Ravensbourne" petrol motor spraying and watering pumps, mounted on a four-wheeled carriage. These handy and compactly arranged pumps have a capacity of 1,000 gallons per hour, and for spraying purposes will serve four or six jets simultaneously. There was another similar pump on a two-wheeled carriage.


THE "RAVENSBOURNE" SPRAYER OF MERRYWEATHER & SONS, LTD., LONDON.

These two machines attracted special attention from the fact that they are the identical machines used on May 6th and 7th for spraying the oak trees in the Ham Cross plantation, Richmond Park, a most interesting experiment, carried out under the direction of Prof. H. Maxwell Lefroy, the celebrated Entomologist of the Imperial College of Science, with the object of destroying caterpillars which of late years have been seriously injuring the foliage of the

trees in the Park. The spraying mixture was lead chromate in solution, and in the course of the test 400 trees, some of them 60 ft. high, were sprayed in two days.

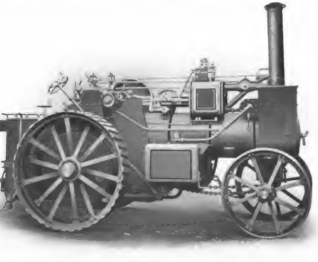
J. AND H. McLAREN, LEEDS.—The accompanying illustration represents one of Messrs. McLaren's "Gold Medal" Steam Tractors specially designed for direct haulage ploughing, and general agricultural work. It is fitted with their patent superheater, feed-water heater, and governors, is spring mounted, and remarkable for its economy and all-round usefulness. They had also on view a standard 8 h.p. single cylinder, and a new design 8 h.p. compound traction engine, together with three of their patent self-lifting direct haulage ploughs.

PETTERS, LTD., YEOVIL.—The Petter "Handyman" oil engine has for long been a favourite for farm and country house work. It is $2\frac{1}{4}$ H.P., and, mounted on a 4 wheeled carriage, it worthily upholds it's name. The Petter stand was specially noticeable this year because it included a large 3 cylinder semi-Diesel engine of 150 B.H.P., said to be the largest ever exhibited at any "Royal" show. Designed to use crude oil, and of massive construction, this engine is of the two stroke type, eliminating all poppet valves and levers. The system of governing used regulates the supply of fuel to the vaporizer in strict proportion to the load, whilst the lubricating arrangements are carefully designed to permit of continuous running at full load for long periods.

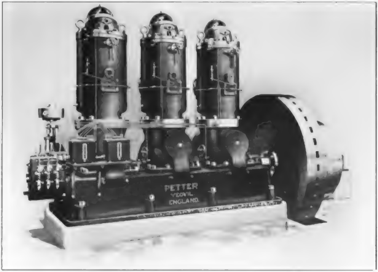
These engines are made in varying powers from 8 B.H.P. to 150 B.H.P., as single, double or 3 cylinder. The single cylinder type is made up to 70 H.P. It is extremely economical in fuel consumption, using under half a pint per B.H.P. her hour.

There was another feature about Messrs. Petters' stand this year—its size, for it was said to be the largest space devoted solely to internal combustion engines.

It is some sixteen years since they took up the manufacture of oil engines, and it is not too much to say that the engines produced by the firm to-day



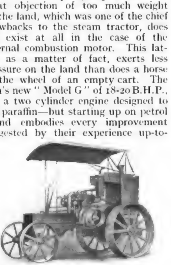
SUPERHEATER TRACTION ENGINE EXHIBITED BY MESSRS. J. & H. McLAREN, OF LEEDS.




150 B.H.P. THREE-CYLINDER CRUDE OIL ENGINE OF PETTERS, LTD., YEOVIL.

are designed on thoroughly scientific as well as practical lines. And yet their engines are so simple and so easy to run that a man of very indifferent intelligence can be trained to run them in a few hours. This is not an unconsidered statement such as is sometimes associated with "show reports," but an actual fact within the present writer's own experience, he having taught a "groom-gardener," who had absolutely no previous experience, to run a "Handyman" engine in three lessons of about an hour each, and the engine remained in the man's sole charge for over a year—in almost daily use. For farm use, therefore, they are invaluable, and the fine display at the Bristol Show gave visitors a good opportunity to see them in various sizes and adapted for many different purposes.

SAUNDERSON AND MILLS, LTD., BEDFORD.—The "Universal" tractor made by this firm is designed specially for direct haulage ploughing, and the general work of a farm. An interesting point emphasised by Messrs. Saunderson and Mills in regard to direct traction ploughing is that the great objection of too much weight on the land, which was one of the chief drawbacks to the steam tractor, does not exist at all in the case of the internal combustion motor. This latter, as a matter of fact, exerts less pressure on the land than does a horse or the wheel of an empty cart. The firm's new "Model G" of 18-20 B.H.P., has a two cylinder engine designed to use paraffin—but starting up on petrol—and embodies every improvement suggested by their experience up-to-

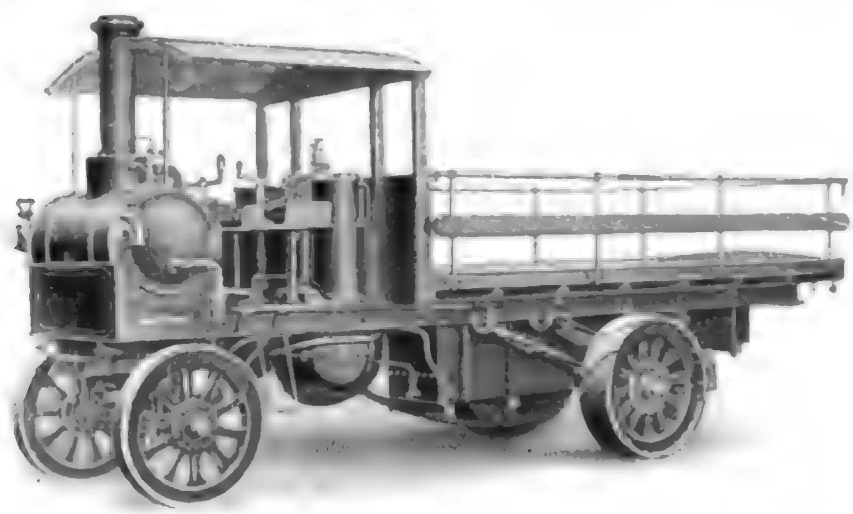


UNIVERSAL FARM TRACTOR SHOWN BY SAUNDERSON & MILLS LTD., BEDFORD.

date. It has proved most successful in working, and achieved the distinction of securing a special—and only—prize for agricultural oil tractors at Port Elizabeth, S.A., in the spring of the present year in competition with 5 other oil driven competitors.

STUDEBAKER, LTD.—We only noticed one light van in the show, that on the Studebaker Co.'s stand. Mounted on a 15-20 H.P., chassis this car has a very smart compact appearance. Straight lines are the dominating feature of the body design, with round side windows placed conveniently for the driver, who is protected in front by an adjustable wind screen. The inside dimensions are :—53 ins. high, 49 ins. long behind the driver's seat, 43 ins. wide, and 35 ins. width of door. The driver's seat is cushioned with curled hair over springs, and the back is kept low, so that he can easily reach for goods in the rear.

THE YORKSHIRE COMMERCIAL MOTOR CO., LEEDS.—The features about the steam wagons of this firm, in which they differ from all others, are mainly in the boiler and the adoption of a vertical type of engine. The boiler has been so long before the public as hardly to need description. It may be described as a modified loco type, having a central firebox from which two sets of fire tubes lead to smoke boxes at either end, and from the smoke boxes return tubes to a central flue situated directly above the firebox. It is placed transversely across the wagon, and the design is such as to ensure 9 inches of water over the firebox, whether on uphill or downhill gradients and irrespective of the degree of gradient. The exhaust from the engine is split up into small jets acting upon the return tubes, which ensures a good steady draught with a minimum of noise. The engine, of the vertical compound type, has cylinders $4\frac{1}{2}$ ins. and $7\frac{1}{2}$ ins. diam. by $7\frac{1}{2}$ ins. stroke respectively, and is placed behind the driver. It is of course entirely enclosed, and all the working parts are well lubricated. All the gearing is of cast steel with machine cut teeth of liberal proportions, the final drive to rear axle being through a steel roller chain. Two road speeds are provided, nominally 6 and 3 miles per hour for the 6 ton wagon, and 8 and 4 miles respectively for the 3 tonner. But if rubber tyres are fitted these speeds may be increased by 50 per cent.



STEAM WAGON MANUFACTURED BY THE YORKSHIRE COMMERCIAL MOTOR CO., LTD., OF LEEDS.

# LARGE STEAMERS AND DOCK ACCOMMODATION

## SOME NOTES ON THE INCREASE IN SIZE

By Adam Scott, M Inst. C.E.

THE advent of the *Aquitania* of the Cunard Line, and of the *Imperator*, and the *Vaterland*, of the Hamburg-America Line, has again emphasised the question of the provision of suitable harbour and dock accommodation for such gigantic liners. The increase in size of the transatlantic liners has been so rapid and extraordinary during the last five or seven years, and has so far exceeded all past predictions and estimates, that it is taxing the powers and finances of the Port Authorities concerned to keep pace with it.

The *Imperator*, which started on her maiden voyage to New York on the 11th of June last, has now displaced the *Olympic* as the largest liner running, and it is interesting to note that for docking her for the first time, the large floating dock of Messrs. Blohm and Voss, at Hamburg, was combined with a section of another dock belonging to the same firm, the joint dock having a lifting capacity of 51,000 tons.

Until the opening last month of the new Gladstone Dock at Liverpool, there was no graving dock which could take in the *Aquitania*. Before that there were only two docks capable of taking the *Olympic*, viz., the Alexandra Dock at Belfast, and the recently enlarged Trafalgar Dock at Southampton; when the *Olympic* was first placed on service, and indeed, at the time of the accident to her last year, there was only the Belfast dock which could take her in, as the Southampton Dock was not then ready. There are now running, the *Olympic*, of 45,000 tons, and the *Imperator*, of 52,000 tons; two more of a similar class, viz., the *Vaterland* and the *Aquitania*, are being fitted out, and are expected to be in

GENERAL VIEW OF THE R.M.S. "OLYMPIC," 46,358 TONS.

THE "LUSITANIA" IN THE CANADA DRY DOCK AT LIVERPOOL.

service next year, while two others are being built, one, the *Britannic*, for the White Star Line, and the other for the Hamburg-America Line. Before the *Imperator*, the Hamburg-America Company's largest vessel was the *Kaiserin Auguste Victoria*, of 24,581 tons, so that at one jump the company more than doubled the tonnage of their largest steamer, an enormous increase. It is true that the abnormally large steamers are few in number,

that they are in a class by themselves, and that only a few of the principal ports are affected by them, but, as we shall show, there has been great expansion in size in the general mail and passenger steamers, and also in the ordinary cargo steamers, and this expansion is still going on. It is the natural consequence of the enormous development of maritime commerce, of the increased imports and exports of every country, of the large increase in volume of the tourist, passenger, and emigration traffic, and of the demands and preference of the well-to-do travelling public for huge and luxurious ships, with their superior steadiness and comfort. Large ships also mean greater bulk-carrying powers, and should make for economy of transport and management. These are the principal factors in the question, the forces behind the shipowners. Putting it briefly, it is owing to the pressure of commercial and economic conditions, and undoubtedly it will be governed in the future, as in the past, by financial considerations, and commercial success—or failure.

Everything points to the necessity, at all the principal shipping centres, for better facilities, more commodious and deeper harbours, and larger graving docks. The problem is a serious one from a financial point of view for Port and Dock Authorities; for after all, it is to them chiefly a question of expense. The construction of steamers of an increasing unit size is not, however, a passing phase, but, as has been said, it is the outcome of a necessity of meeting modern commercial conditions, and while the trade of the country, and of the world, continues to expand by leaps and bounds, the tendency will be to build generally larger vessels. This tendency has been, and no doubt will continue to be, hindered by the want of adequate harbour and dock accommodation, especially as regards depth of water. Owing to this insufficiency in depth, many vessels cannot be loaded down to their marks, but if larger vessels of all classes are built, accommodation must be provided for them: this will be forced upon Port Authorities generally in a greater or less degree, and those which anticipate and make the most suitable provision for the future will undoubtedly be the first to reap the benefits. Some of the minor ports will probably suffer decay owing to natural defects, faulty location, and the difficulty of modernising them excepting at a cost which would not be justified. It is only a very few of the first-class ports which can

THE NEW CUNARD LINER "AQUITANIA" AFTER LAUNCHING (47,000 TONS).

THE "IMPERATOR" OF THE HAMBURG-AMERICA LINE (52,000 TONS).

attempt to provide accommodation for the great super-liners of the Atlantic. These ships are, therefore, restricted in their calls, and while this is so it will be feasible to deal with them.

In 1893, going back only 20 years, the largest liner was the Cunarder *Campania*, length 622 feet, breadth 65 ft. 3 ins., draught 25 ft., gross tonnage, 12,950 tons, I.H.P. 30,000, and speed 22 knots. In 1901 came the White Star *Celtic*, of 20,904 tons (the first vessel to exceed 20,000 tons, leaving out the old *Great Eastern*) and 21 knots speed. The *Campania* held the speed record until the German lines took up the running with the appearance of the Hamburg-America *Deutschland*, in 1900, of the North German Lloyd *Kaiser Wilhelm II.* in 1903, and the same company's *Kron Princessin Cecilie*, in 1907. These vessels, with a speed of 23.5 knots held the record from 1900 to 1907, when it was wrested from them by the magnificent Cunarders *Lusitania* and *Mauretania*, which still hold pride of place for speed, with records up to 25½ or 26 knots. In 1911 came the *Olympic*, with a gross tonnage of 45,000, increased by her recent alterations to 46,358 tons. Now we have the *Imperator*, 52,117 tons, launched 23rd May, 1912, the *Vaterland*, launched 3rd April, 1913, and the *Aquitania*, 47,000 tons, launched 21st April, 1913. In Table No. 1, a list is given of vessels which may be taken as typical of the development made in liners during the last 20 years. It will be seen that during that period the tonnage of these huge Atlantic liners has increased about four times. Comparing the dimensions of the *Campania* with those of the *Aquitania* we find an increase of 50% in the length, nearly 49% in the beam, 36% in the draught, and

263% in the tonnage. Of course, this is a rate of increase which cannot continue much longer, however feasible it may be technically or practically to build larger vessels. Apart from these special liners, however, the increase in size has been general and extends from the first-class mail and passenger steamers down to cargo steamers. The total number of British and foreign steamers of 100 tons gross and upwards recorded in Lloyd's Register for the year 1903 was 17,761, for the year 1913 the number was 23,897. The total gross tonnage of these steamers was 27,183,365 tons for 1903, and 43,079,177 tons for 1913; the average tonnage per ship for the same years being 1530.5 tons and 1802.7 tons respectively.

In Table No. 2 a comparison is made of the number of steamers of various

TABLE No. 1.

| Year. | Ship. | Line. | Length over all. | Beam. | Depth moulded. | Draught. | Gross Tonnage. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 1893 | *Campania* | Cunard | 622' 0" | 65' 3" | 41' 6" | 25' 0" | 12,950 | |
| 1901 | *Celtic* | White Star | 689' 9" | 75' 4" | 44' 2" | 31' 0" | 20,904 | |
| 1903 | *Cedric* | " " | 689' 9" | 75' 4" | 44' 2" | 33' 0" | 21,035 | |
| 1906 | *Adriatic* | " " | 709' 2" | 75' 6" | 52' 7" | 34' 0" | 24,541 | |
| 1907 | *Lusitania* | Cunard | 785' 0" | 87' 10" | 60' 4" | 33' 6" | 31,550 | |
| 1911 | *Mauretania* | " | 790' 0" | 88' 0" | 60' 6" | 33' 6" | 31,938 | |
| 1912 | *Olympic* | White Star | 883' 0" | 92' 6" | 64' 3" | — | 46,358 | |
| 1913 | *Imperator* | Ham-America | 918' 7"* 909' 9" | 98' 0" | 63' 0" | 35' 6" | 52,117 | |
| 1913 | *Vaterland* | " " | (Dimensions not yet given out) | | | | — | Fitting out |
| 1913 | Another not yet named. | " " | (Dimensions not yet given out) | | | | — | Building. |
| 1913 | *Aquitania* | Cunard | 902' 0" | 97' 0" | 64' 0" | 34' 0" | 47,000 | Fitting out |
| 1913 | *Britannic* | White Star | (Dimensions not yet given out) | | | | — | Building. |

* Length over figure-head.

TABLE NO. 2.

| Tonnage Range. | Year ended June 30th, 1903. | Year ended June 30th, 1913. |
|---|---|---|
| 1,000 and under 1,500 | 603 | 505 |
| 1,500 " " 2,000 | 526 | 428 |
| 2,000 " " 3,000 | 1017 | 673 |
| 3,000 " " 4,000 | 939 | 1170 |
| 4,000 " " 5,000 | 397 | 824 |
| 5,000 " " 7,000 | 289 | 468 |
| 7,000 " " 10,000 | 106 | 209 |
| 10,000 " above .. | 39 | — |
| 10,000 " under 12,000 | — | 59 |
| 12,000 " " 15,000 | — | 41 |
| 15,000 " " 20,000 | — | 15 |
| 20,000 " " 30,000 | — | 4 |
| 30,000 " " 40,000 | — | 2 |
| 40,000 " over | — | 2 |

LAUNCH OF THE GERMAN LINER "VATERLAND," OF THE HAMBURG-AMERICA LINE, APRIL 3RD, 1913.

WHITE STAR LINER "OLYMPIC" (46,358 TONS) IN DRY DOCK FOR ALTERATION.

ANOTHER VIEW OF THE "OLYMPIC" IN DRY DOCK.

**TABLE No. 3. SHOWING THE DIMENSIONS AND TONNAGE OF THE LARGEST STEAMERS, AND THE AVERAGE GROSS TONNAGE PER SHIP OF THE FLEETS OF A FEW OF THE PRINCIPAL LINES FOR THE YEARS 1903 AND 1913 RESPECTIVELY.**

| Line. | Allan. | | Anchor | | Canadian Pacific. | | Orient. | | P. & O. | | Union | Castle. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year. | 1903. | 1913. | 1903. | 1913. | 1903. | 1913. | 1903. | 1913. | 1903 | 1913. | 1903 | 1913. |
| Steamer's Name. | *Tunisian.* | *Alsatian & Calgarian.* (now building. | *Columbia.* | *Cameronia.* | *Lake Manitoba.* | *Empress of Asia & Empress of Russia.* | *Orontes* | *Orama.* | *Marmora.* | *Maloja.* | *Walmer Castle.* | *Balmoral Castle.* |
| Length .. .. | 512' 0" | 600' 0" | 375' 0" | 535' 0" | 469' 5" | 590' 0" | 513' 9" | 551' 0" | 530' 0" | 550' 0" | 570' 6" | 570' 0" |
| Breadth .. .. | 59' 2" | 72' 0" | 46' 0" | 62' 0" | 56' 2" | 68' 0" | 58' 3" | 64' 3" | 60' 3" | 62' 9" | 64' 5" | 64' 6" |
| Depth .. .. .. | 24' 6" | 54' 0" | 30' 0" | 36' 0" | 31' 9" | 46' 0" | 34' 5" | 39' 0" | 34' 0" | 34' 4" | 38' 8" | 38' 11" |
| Draught .. .. | 14' 1½" light 28' 1½" loaded. | 19' 3" light 28' 6" loaded. | — | — | — | — | — | — | 28' 8"<br>— | 29' 7"<br>— | 30' 11½"<br>— | 31' 5½"<br>— |
| Gross registered Tonnage of Ship .. | 10,576 | 18,000 about. | 8,292 | 10,963 | 9,674 | 16,850 | 9,023 | 12,928 | 10,509 | 12,431 | 12,546 | 13,361 |
| Average gross registered Tonnage of the Ships of the Fleet .. .. | 4,520 | 7,784 | 4,376 | 7,450 | — | — | 6 553 | 10,822 | 5,961 | 7,591 | 5,845 | 7,391 |
| | | | | | 2 building, 520' 0" long 64' beam, 12,500 tons gross, draught 27' 6" | | New steamer building of 14,000 tons. | | | | | |

**TABLE No. 4. COMMERCIAL GRAVING DOCKS: SOME OF THE LARGEST BUILT AND BUILDING.**

| | Length. | | Width of Entrance. | Width of Body. | | Depth on Sill. | Depth on Blocks. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| Avonmouth .. | 875' 0" over all | 850' on blocks | 100' 0" | — | — | 32' 0" | — | — |
| Belfast .. .. | 901' 0" from caisson in outer stop to coping | 850' 0" on floor | 96' 0" | 100' at bottom | 128' at coping | 35½' 0" at H.W. | 32' 9" on blocks at H.W. | — |
| Bombay .. | 1,000' 0" at coping | — | 100' 0" at H.W. | — | — | 36' 0" at H.W. about | — | Building; to be ready 1914. |
| Bremerhaven .. | 869' 10¾" with outer stop | — | 134' 6" at top. 113' 2" below. | — | — | 37' 11" at H.W. | — | — |
| Esquimalt .. | 900' 0" | — | 128' 0" | — | — | 41' 0" | — | Building. |
| Glasgow .. .. | 880' 0" at coping level | — | 85' 0" at H.W. and at sill level | 78' 4" at floor level | 115' at coping | 26' 6" at H.W | 25' 4" on blocks | A larger dock to be built. |
| Havre .. .. | 1,023' 4" useful length | — | 124' 8" | 131' 3" at bottom | 171' 10¾" at coping | 27' 3" at L.W. 52' 11½" at H.W. | —<br>— | Building. |
| Liverpool-Canada Dock .. .. | 925' 6" | — | 94' 0" | — | — | 31' 10" at H.W | — | — |
| Liverpool - Gladstone Dock .. | 1,050' 0" from face of caisson to head of dock | — | 120' 0" | 141' at bottom | 155' 6" at coping | 15' 0" at L.W. 46' 0" at H.W. | | —<br>Just opened. |
| London - Tilbury .. | 868' 0" at coping | 841' on blocks | 77' 0" | — | — | 32' 9" at H.W. | — | — |
| Newport - News, Va., U.S.A. .. | 804' 0" | — | 87' 0" | — | — | 30' 0" at M.H.W. | — | — |
| Singapore .. | 865' 0" at coping | 859' on blocks | 100' 0" at coping | — | — | 34' 0" at H.W. | — | Building. |
| Southampton .. | 897' 0" from caisson to dockhead | — | 100' 2" | 102' 0" at lower altar | 125' 0" at coping | 35' 0" at H.W. | 33' 0" on blocks | Blocks can be lowered. |
| Tranmere .. .. | 861' 0" at coping | 861' on blocks | 95' 0" | — | — | 33' 7½" at H.W. | — | — |

STERN VIEW OF THE "MAURETANIA" IN DRY DOCK AT LIVERPOOL.

grades of tonnage, from 1,000 tons and upwards, built and owned in the United Kingdom, and entered in Lloyd's Register for the years 1903 and 1913. This table shows conclusively that the number of steamers between the range of 1,000 and 3,000 tons is decreasing and that the number above 3,000 tons is largely increasing. The average net registered tonnage of vessels which entered and left the Port of London, and paid dues in 1902 was 518 tons, for 1912 the average was 636 tons. For Liverpool the similar figures are 549 tons for 1902, and 737 tons for 1912. For the Tyne the averages for the same years are 670 and 847 respectively. The number of vessels which entered the Port of Glasgow in 1902 with a net registered tonnage ranging between 4,000 and 6,000 tons was 41, and with a net

registered tonnage of 6,000 tons and upwards, only 2; the similar figures for 1912 were 192 and 39 respectively. The largest ship which passed through the Suez Canal in the year 1900 was the *Grosser Kurfurst* (Norddeutscher Lloyd) having a gross tonnage of 13,403 tons. Since 1909 the largest vessel using the Canal is the *Cleveland* of the Hamburg-America Line, with a gross tonnage of 17,342 tons. The gross average tonnage of vessels passing through the Canal was 3,981 in 1900, and 5,213 tons in 1912.

The Orient Line is building a steamer of 14,000 tons. The Royal Mail Steam Packet Company, and its incorporated Company, the Pacific Steam Navigation Company, are both building steamers of about 15,500 tons gross. The Allan Line has two vessels of about 18,000 tons building for the Canadian Service. On the Australian Service *via* the Cape, the White Star Line has just placed the *Ceramic* of 18,000 tons, and it is almost safe to predict that in another ten years vessels of double this tonnage will be running to Australia *via* the Panama Canal, which will be able to pass vessels of 47,000 tons or more. The Canadian Pacific Railway Company have increased the size of their steamers on the Pacific route—Vancouver to Japan and China—from 6,000 tons to 16,850 tons gross, and on the Australian route from 8,075 to 13,500 tons gross, and have at present two vessels building, each of about 12,500 tons gross. The Pacific Mail Company's largest steamers running from San Francisco to Japan and China, have a displacement of 27,000 tons; while the Great Northern Steamship Company have one steamer, the *Minnesota*, with a length of 730 ft.,

ANOTHER VIEW OF S.S. "MAURETANIA" IN DRY DOCK AT LIVERPOOL.

STERN VIEW OF S.S. "CERAMIC" (ABOUT 18,000 TONS), SHOWING BLADES.

a gross tonnage of 20,718 tons, and a displacement of 37,500 tons, running between Seattle and Hong Kong.

There does not appear to be any particular reason for sudden great increments in the sizes of cargo steamers, but in the ordinary course of progress, they will go on increasing, probably at the gradual rate which the past has shown, until they approach more nearly to the size of the intermediate class of liners of to-day. They are practically debarred from a faster increase, because of want of depth of water at the generality of their ports of call—ports which cannot afford to spend much in obtaining greater depth.

Vessels of war have reached a length of 725 ft., and have beams of 94 and 98 ft., the latter figure being equal to that of the mammoth liners. If they continue to increase in size during the next five years at the same rate as they have been doing recently, either new docks or a general reconstruction of naval docks will be necessary.

Table No. 3 illustrates the increase in size during ten years—from 1903 to 1913—of the ships of the fleets of some of the principal lines, and in every case the average gross registered tonnage of the fleets has largely increased.

The Suez Canal will doubtless remain the chief route from Europe to the Far East, and its depth will govern the size of vessels trading on that route. Its depth at present exceeds 9.50 metres (31.16 ft.) at low water throughout its length, and it is intended to increase that depth to 12 metres (39.36 feet), but this will not be attained for some years yet, and when it is, it will probably be found necessary to increase it to 13 metres (42.64 feet), in order to put it on quite equal terms with the Panama Canal. From the 1st of January, 1914, the authorised draught of water for the Suez Canal will be increased by one foot, thus bringing it to 29 feet. The Panama Canal locks are 1,000 ft. by 110 ft. with a depth of 40 ft. on

the sills, and it may be assumed that before very long they will be taxed to their utmost limits, as we have now vessels approaching 100 feet in breadth and over 900 ft. in length. The locks of the Kaiser Wilhelm Canal are being made 1,083 ft. by 148 ft. with 45 ft. depth on the sills, but as this is chiefly a stragetic canal, it will not particularly influence the size of merchant vessels. Under the present dredging programme, the navigable channel of the Thames is to have a depth of 30 ft. at low water from the Nore up to the Royal Albert Dock, and between the Royal Albert Dock and the Tower Bridge there is to be a depth varying from 20 ft. to 14 ft. at low water. In 1907 the writer advocated a low water channel of 35 ft. up to Gravesend, and is still of opinion that such a depth should be provided up to Tilbury docks, opposite to Gravesend. Under the new programme of works of the London Port Authority, locks and graving docks of the following dimensions were proposed, but are not in the immediate programme for execution:—

North Albert Dock—Lock 1,000 ft. by 120 ft. with a depth of 52 ft. at H.W. Graving dock, 1,000 ft. by 120 ft. with a depth of 40 ft.

Tilbury Docks—Lock, 1,300 ft. by 130 ft. with a depth of 55 ft. Graving dock, 1300 ft. by 130 ft. with a depth of 45 ft.

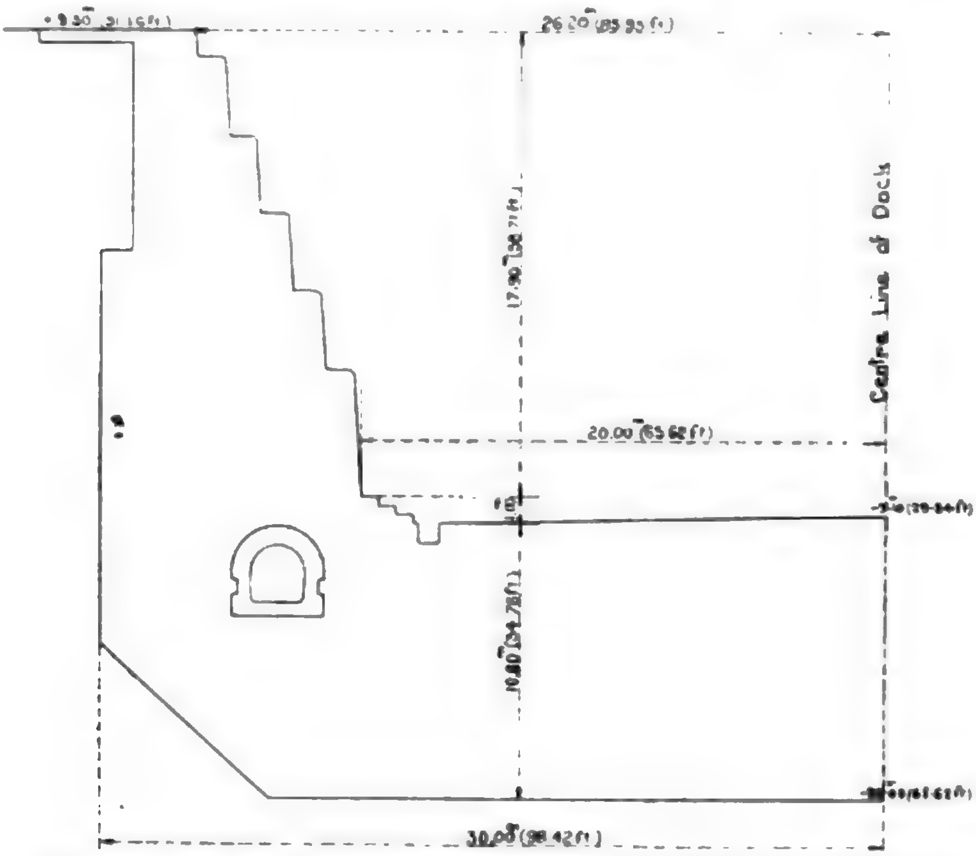
Amongst the works now being undertaken at the South Albert Dock are a lock 800 ft. by 100 ft. with 45 ft., depth at H.W., and a graving dock, 650 ft. by 100 ft. with 35 ft. depth on the blocks. It will thus be some years yet before the Chief Port will be able to say that it can dock the large liners. On the Mersey bar there is a depth of 30 ft. at low water, and of 59 at H.W.O.S.T.; in the Channel between the bar and Liverpool the minimum low water depth may be taken at 30 ft. The low water depth at Liverpool varies from 60 ft. to 80 ft. In the new Gladstone Dock, which has just been

STERN VIEW OF THE "IMPERATOR" IN FLOATING DOCK AT HAMBURG.

opened, Liverpool again possesses the largest graving dock, and the only one capable of taking the *Aquitania*. It is designed to serve both as an ordinary wet dock and as a graving dock, and has a length of 1,050 ft. from face of caisson to dock head, a width of entrance of 120 ft., a depth on the sill of 15 ft. at L.W., and of 46 ft. at H.W.

The depth of water in the approach channel to the docks at Southampton is 35 ft. at L.W. The Trafalgar Dock there, belonging to the London and South Western Railway Company, is reported that the Hamburg-America Company have purchased a large paddle steamer for service as a tender in Southampton waters. The new lock at Portsmouth, with a length of 850 feet, a width of 110 ft., and a depth of 46 ft. 6 in. at H.W.O.S.T. will be available as a graving dock. The new dock of the Newport and South Wales Dock Company has a lock 1,000 ft. long by 100 ft. in width, and a depth at H.W.O.S.T. of 45 ft. on the outer sill, and of 38 ft. on the inner sill.

At the Tyne the channel of the river




HALF SECTION OF HAVRE NEW GRAVING DOCK NOW IN COURSE OF CONSTRUCTION.

likely to remain the largest on the South Coast for some time.

It may be noted that though the Port of Southampton can take the largest vessels at any state of the tide, and is perfectly sheltered, it is at a disadvantage owing to its narrow and crowded waters for the handling of such huge vessels as the recent Atlantic liners; this was exemplified in the *Olympic-Hawke* collision, and by the fact that last month when the *Imperator* called on her first voyage to New York, she lay off in the Solent and embarked her passengers by tender. It is

from the sea to Northumberland Dock, a distance of about 3½ miles, is now being dredged by the Commissioners, to a depth of about 30 feet at L.W.O.S.T., and for a distance of about 11 miles up from Northumberland Dock to a depth of about 25 feet at L.W.O.S.T.

The Clyde navigation from Port Glasgow up to Glasgow Harbour has a depth of 22 to 23 feet at L.W., or 33 to 34 feet at H.W., and deepening is being carried on to 25 feet at L.W. The Clyde thus can only take the largest vessels at the time of H.W. Glasgow

had no graving dock capable of taking the *Campania* when she was built in 1893, and she had to be docked at Liverpool. So also will it be with the *Aquitania*. The Clyde trustees obtained powers for a new graving dock in 1911, but it has not been commenced yet.

At the present moment there is no graving dock, either on the Continent of Europe or in America, capable of taking a vessel of the dimensions of the *Olympic*. Germany's largest is at Bremerhaven. France has a very large and important dock in construction at Havre for the mercantile marine, which when completed in 1919 will have the greatest depth on sill at H.W. of any graving dock in the world. The length will be 1,023 ft. 4 ins.; width of entrance, 124 ft. 8 ins.; and depth on sill, 52 ft. 11½ ins. at H.W. By the courtesy of the Resident Engineer, Mr. M. Fay, a half section of the dock is shown in the illustration. The United States has recently completed three important naval docks, one at New York, length 694 ft. 6 ins., width of entrance 112 ft., and depth on sill 35 ft. 5½ ins. at M.H.W.; one at Norfolk, Va., length 722 ft. 11 ins., width of entrance 101 ft., and depth on sill 34 ft. 0¾ ins. at M.H.W.; and the third on the Pacific coast at Puget Sound, length 827 ft. 6 ins., width of entrance 114 ft. 4 ins., and depth on sill 38 ft. at M.H.W. A dry dock is being built at Esquimalt, with a length of 900 ft., a width of 128 ft., and a depth of 41 ft. A contract has just been let for a large dry dock at Quebec, while others are spoken of at Toulon, Sydney (Nova Scotia), and elsewhere. Table No. 4 gives particulars of the largest commercial graving docks, built and building. The gradual increase in size of the ordinary mercantile marine will mean that many firms which do repairing work will be faced with the serious question of providing larger docks, whether they will or not, if they are to hold their own in the pressure of competition. Shipbuilders will also be affected, and will probably have to reconstruct old or provide new graving docks. It is probable that floating docks may come into more general use than they have done in the past.

The International Navigation Congress, held at Philadelphia last year, came to the conclusion that :—

"It is essential that each port should be systematically organised for the accommodation of the traffic and the industries to be served. Experience shows the need of supplementing the use of privately developed terminals by the public ownership or control of the operation of wharves, docks, warehouses, and other harbour facilities for handling freights for public use. Exclusive private ownership of water terminals is indefensible."

There is a good deal to be said in favour of some kind of public assistance or control as against exclusive private control. Fast liners are subsidised, and there seems no good reason why important ports should not be so. The principle is admitted by the Development Act, by which State assistance is being given to minor ports. In 1910 Canada passed a dry dock Subsidies Act, by which the Government can grant a subsidy of 3 per cent. on the capital expenditure on any dry dock scheme, if the conditions imposed by the Department of Marine are complied with. Before this Act was passed, assistance could only be given to such works by Special Act, and was thus given for various docks. Shipbuilders are agreed that there is no technical difficulty in building still larger vessels. The dimensions of docks and depth of waterways practically constitute the limit in the size of ships, but at the same time it does not necessarily follow that given these facilities ships of much larger size than those now existing would be built. It is probable, as regards the leviathans, if they should increase much more in size, that the beam and draught will in the future show a greater proportional increase than the length, notwithstanding that the provision of depth is the most serious question for Port Authorities.

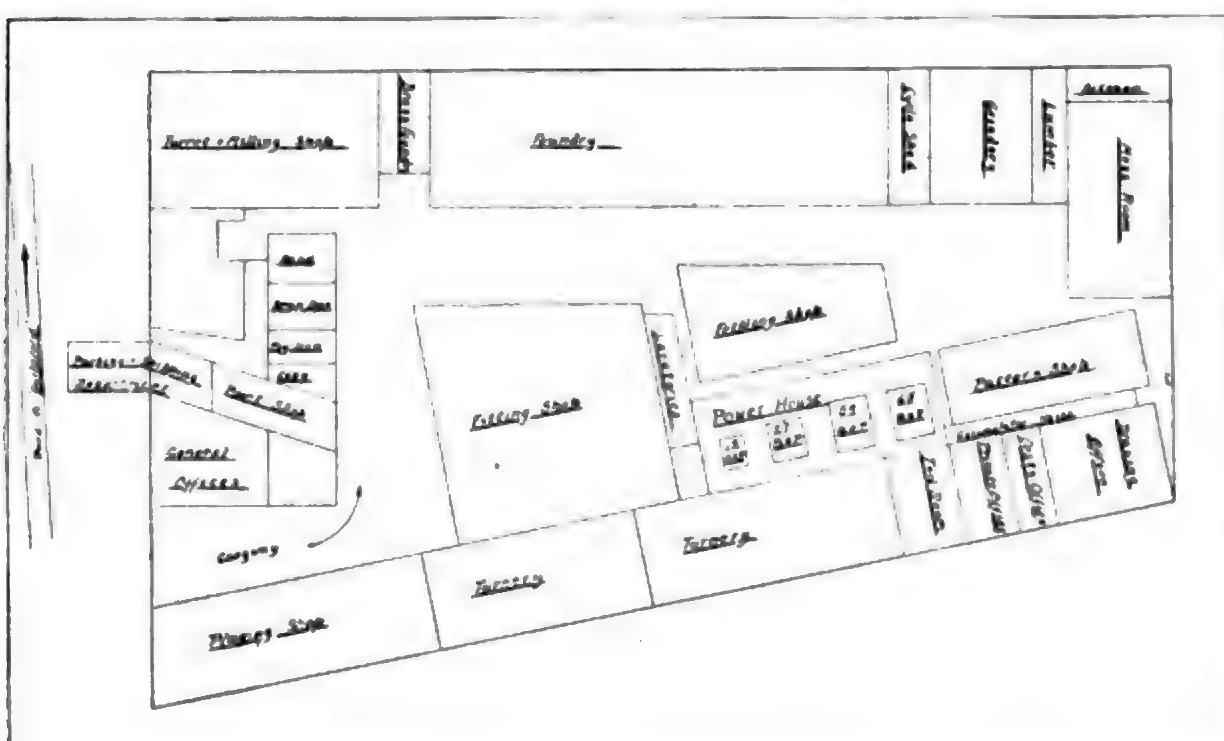
Our ports are our only outlet for our Colonial and foreign trade, and for us, above all other countries, it is important that they should be second to none in facilities, if we are to retain our commercial and shipping supremacy.

# THE WORKS AND MANUFACTURES OF DRUMMOND BROTHERS, LIMITED, GUILDFORD

**By a Staff Correspondent**

At Worplesdon, a mile or two out of Guildford, that somewhat sleepy town of Surrey, the works of Drummond Brothers, the toolmakers, are certainly very much awake. Surrey, as a county, was from the first a favourite touring ground for cyclists and motorists, but it was the latter who appeared to have prompted the initial step of founding the works at Rydes Hill. It was not much of a start—one man and a boy, the latter combining in himself the duties of shop sweeping and motive power. To-day, the firm employ over 250 men and boys. They have grown thus quickly, because they started out to fill a gap. The motor car was new, and there were no special tool makers, for they were busy and unable to go out of their way to supply tools for repairing motors. So Drummond Brothers had a fairly unencumbered track to set forth upon, and they laid themselves out to supply that sort of machine tool which was wanted for carrying out small part repairs, the machine tool for the motor garage and, incidentally, the machine tool which has also found a demand among general amateurs. A small lathe, capable of taking an article of 4 inches radius, and purchaseable for £5, and possessing the accuracy of a high-class expensive tool, was a novelty which deserved to succeed, and it has done so.

The ground occupied by the works is by no means too large, and it is anticipated that, before long, the heavier work will be transferred to a new shop to be built on a recently purchased site nearer to the town. On the present



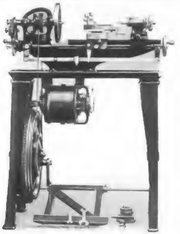

PLAN OF THE WORKS AT WORPLESDON, GUILDFORD.

TURRET AND MILLING SHOP.

site of 2 acres there is a foundry, the turret machine shop, fitting shop, drawing office and stores building, milling, turning, grinding and planing shops, and a power house containing a 65 h.p. Diesel engine, a 55 h.p. Hornsby oil engine, a 28 h.p. engine, and an 18 h.p. engine all using oil fuel and aggregating 166 h.p. There are also the usual sand, and other stores and offices. No very heavy work is done, so that the foundry work is simple, and, except for a few heavy beds, is chiefly made up of light beds, brackets, and detail parts. The cupola is blown by a Roots blower driven by a Clayton oil

TURNERY.

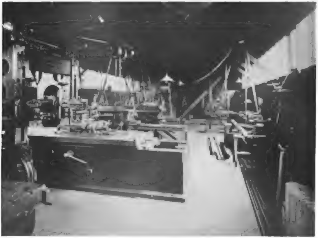
engine, with a stand-by drive from the turret shop shaft which is electrically driven. A few machine tools are driven by their own motors, but gener-



DRUMMOND BROS., LTD., NEW DESIGN BORING AND SCREW CUTTING LATHE, EQUIPPED WITH ELECTRIC MOTOR.

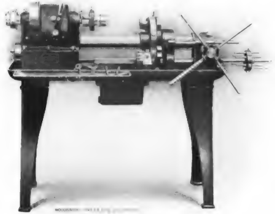
ally the system of driving is by shafts which are electrically driven, and each shaft drives several tools, a modified group system drive. All machine beds after casting and fettling are allowed to lie by for a time before being machined. They are then rough planed, and this relieves them of their surface stresses when they are again allowed to rest and come to shape. When finish-planed they move very little further, and are given the final scraping to the required limit of accuracy. The small lathe beds are continuous bearing—not girder beds, so that there is little chance of any distortion through work stresses.

A special machine is the Ring Turret shown in the illustration. This tool has a stout circular bar bed upon and round which the turret rotates. It is intended for the production of articles from the solid bar or tube. The bar bed extends from the head-stock. This carries a large hollow-spindle in gun-metal parallel bearings. The head carries a chuck, which can be released or gripped while the lathe is running. The drive is upon a constant speed large diameter pulley from the line shaft for ordinary work, or from a reversing counter shaft, if required. Reduced speed is given by a black gear. The turret which, as said, runs on the bar bed, is large in diameter, and is



PLANING SHOP.

worked by hand to the required position and guided then on its forward movement by a bar which fits ways on the rim of the turret, and there is a stop hole in the spindle, an 8 inch pulley for a 2 inch belt, and a 12 inch diameter turret with 6 stops. The turret traverse is 12 inches, and the machine measures



RING TURRET LATHE MANUFACTURED BY DRUMMOND BROS., LTD.

flange holding a stop bar for each tool held in the turret. The tool described has $3\frac{1}{2}$ inch height of centres with a $1\frac{1}{4}$ 5 ft. 6 in. overall length, and with its oil catcher bed and legs weighs 530 pounds. For a small bench lathe the

LOWER FOUNDRY.

FITTING SHOP.

same circular ground bar head is employed for sliding, boring, milling and screw cutting, an excellent tool for the model maker just under 3 ft. overall length, the bed bar being 3 inches diameter and the centres 4 inches in height, permitting of 8 inches work over the bed, or 6 inches over the saddle. The simple machine without stand or foot motor is sold for £5 10s. 0d. Norton grinding machines are employed on the grinding of the bar bed and the limit of accuracy is .0001 inch.

This machine is a regular lathe with headstock, change gears, face plate, saddle with traverse and swivel tail stock, &c.

The firm's small lathe with regular bed has 3½ centres, and a flat bottom bed 2 ft. 6 in. long, the total length being 3 ft. It has a gap for 9½ inch work up to 2 inches wide, and a cord drive from a heavy 73 lb. treadle driven fly wheel. The bed box is of section similar to the beds of larger lathes. The saddle ways are double, the lateral guidance being taken on the front way. The bed is stiff in itself, and requires no aid from the tray or standards. The lead screw is placed outside the bed, but central with the saddle guide. The tail stock is guided like the saddle, and locked by a single lever both to the front guiding way and to the bearing ways. The illustration shows this lathe with an electric motor applied below the bed, and driving the fly-wheel by means of a small pinion.

A special tool is the Drummond-Barreto, a Universal machine for turning, boring, drilling, screw cutting, milling, and even gear cutting. It turns articles from ¼ to 36 inches diameter, and is correctly speeded for this range, and will run from 5 to 270 r.p.m. It can be varied from 7 to 18 inches centre height. In gear cutting it will cut spurs, mitres and worm gears up to 40 inches diameter. This special machine is in itself a complete tool for a motor garage, and literally a creation of the motor industry. Another larger size tool, which we described in our last issue, is the new 9 inch and 12½ inch centres lathe, the result of a Colonial journey which showed that there was a field for it on account of the wide variety of work undertaken by Colonial shops. These few machines will serve to show the class of products put forth by a shop that has grown up with and upon a new industry, and laid itself out to meet the conditions to which that new industry has given birth.

# Current Topics

### Cost and Accuracy.

MANY makers of light machinery and appliances advance accuracy as one of the most important selling points of their products, and cause it to be regarded as a justification for purchasers to pay an enhanced price for the article. The fact is overlooked that accuracy means economy of manufacture in most cases, and that the argument is therefore rather a double-edged one to wield. Taking such apparatus as automatic machines, rifles, motor bicycles, small gas and oil engines, typewriters, etc., as instance, it is undoubtedly the fact that far cheaper production is attained by making the various parts of each of these interchangeable. Interchangeability implies the minimization of fitting, assembling and erecting, the simplification of progress systems for the parts going through the shops, and the speeding up of machining processes by the use of jigs and fixtures. All these things tend towards economy, but, first and foremost, towards accuracy. From this it will be realised that it is often somewhat illogical to pay more for an accurately finished machine than for one which has cost more to make owing to its lack of accuracy. It is not always convenient for the manufacturers of such apparatus to point this out to purchasers, but it is nevertheless true. As examples of the volume of business to be built up largely by interchangeability, or accuracy in manufacture, and quantity of production. American motor car builders may be cited, some of whom can turn out a 20 h.p. car complete for £50 factory costs, including material.

### Low Head Water Power Stations.

THERE are many situations in this country where low heads are available for small water power electrical stations. The drawback to such low head stations is that the water turbines and equipment are necessarily of considerable bulk, weight and cost, and as a consequence the governing for speed is adversely affected. One method of overcoming, as far as possible the latter difficulty, and one which could profitably be applied to many of the potential installations in this country, consists of applying a storage battery for regulation of the voltage whilst the battery is, of course, also available for stand-by purposes and for helping at times of heavy load.

In this connection, therefore, it may be of interest to present a few particulars of such a scheme, installed at Lawrence, Kansas. In this case the head is 12 feet, and a 400 ampere-hour 600 volt storage battery is utilised to regulate, and aid on peak loads, the

600 volt direct and 440 and 2,300 volt alternating current systems, which are interconnected through transformers and motor generator sets. Whilst the battery is normally on the d.c. system, it exercises its regulating effect on the a.c. circuits as well, through the transformers and converting apparatus. The action of the battery is to absorb through booster balancer sets, and adjust sudden variations in the load, which would otherwise cause hunting up or down of the water wheel governors. Although this plant produces both alternating and direct current, the principle of battery regulation could obviously be applied and with greater simplicity, to a station generating either form of current alone.

### Electric Motor Capacities.

THE features which limit the capacity of a motor are the temperature rise and the shape of the efficiency curve. In well designed and properly applied motors, except in unusual cases where the reverse conditions are only to be expected, the latter factor should be of the first and the heating of only secondary importance. This is, of course, as it should be, but as in many cases, it is not. The rated capacity of a motor should not be determined by the temperature rise, but should be such that the motor may be operated at the equivalent output with the greatest all-day efficiency, as shown by the efficiency curve. On many of the best motors, the rating is so low that temperature rises of only 20°C. to 30°C. will be engendered by continuous full-load running. By keeping the ratio, and consequently the temperature rise for rated load, low, two things are accomplished. In the first place, a big overload capacity is available before the machine will stall or pull out, and secondly, the power factor of the alternating current supply system is adversely affected. It is a matter for the user to decide whether the value of the former out-balances the effect of the latter, but in the case of "motors on the mains" he could hardly expect a central station willingly to recommend the motor of low rating, on account of the bad effect such a proceeding would exercise on its system if that policy were generally followed.

### Limits to Economy in Small Turbines.

IN striving after the utmost operating economy in steam power plant, the fact should never be lost sight of that first cost and reliability are factors which have very important effects upon the ultimate financial balance. Take the case, for instance, of small steam turbines for driving exciters, pumps, or similar auxiliary machinery. The average efficiency of such small steam turbines is between 25 per cent. and 40 per cent., but so far as only technical considerations and possibilities are concerned, there is no good reason why this figure should not be carried up to approach 65 per cent. and the efficiencies of larger turbines. Efficiency is determined by the peripheral speed of the turbine wheels and by the number of stages. For instance, a single stage machine running at 2,500 r.p.m. with a 2 ft. diameter rotor, and four reversals, would be about 35 to 40 per cent. efficient, but by increasing the wheel diameter to 4½ ft. the efficiency would come up to about 60 per cent. Now first cost follows very nearly the square of the wheel diameter in small turbines, so that a 100 h.p. machine, designed with a 2 ft. wheel for the lower efficiency, would only be about one-fifth the price of one with a 4½ ft. wheel for the higher efficiency figure. As regards reliability, the wheel stresses in the second machine would be about five times as much as those in the smaller wheel. The morals to be drawn from the above are, that in ordering small turbines the question of first cost for various performances should be very carefully investigated, and that reliability should never be sacrificed to a highly economical water rate.

# BOOK NEWS

### Liquid Steel: Its Manufacture and Cost.

David Carnegie, assisted by Sidney C. Gladwyn. Longmans and Co., London, 1913. 25s. net.

In these modern times of industrial progress and strenuous competition. the importance of applied science has been usefully recognised in combating the conditions met with, but the added burden of legislative taxation has rendered further economies paramount, which can perhaps best be attained by the reduction of costs in manufacture, hence we welcome the writer who gives these considerations special prominence, both in regard to initial cost of plants described as well as working expenses. Although the value of such costs is more or less relative owing to local considerations in each individual case, allowance being made for these, the voluminous estimates and costs contained in the present volume should be of extensive use in practically effecting that economy in manufacture which should be the aim of every successful manufacturer.

This useful work contains 10 plates and 252 illustrations relating to the principal processes in use in the manufacture of steel at the present time, and it is only doing bare justice to the authors in paying a deserved tribute to their discriminative selection of subject matter and their able treatment of it.

On perusal we find over 500 pages of useful information to the student who is inclined to take his lesson in prime costs in connection with the production of "Liquid Steel."

### Fire Protection in Buildings.

By Harold G. Holt, A.R.I.B.A. Crosby, Lockwood and Son. London, 1912. 8s. 6d. net.

This volume embodies the matter contained in various articles contributed by the author to technical journals, amplified, however, and brought fully up-to-date. It is divided into two parts, the first dealing with construction and the second with fire extinction. In the former, general memoranda of terms and standards are given, with a foreword on the work of the British Fire Prevention Committee. Complete isolation, limitation of cubical contents, frame and floor construction, fire resisting doors, and column protection are fully discussed, accompanied by illustrations and diagrams showing the different systems and the effects of fire upon them. In the latter part, the opening chapter is devoted to the cause of fire outbreaks and methods of prevention of some the more frequent, while in the succeding chapters chemical extincteurs, sprinkler and hydrant systems are described, and their efficiency contrasted. Appendices include L.C.C. regulations, Fire Offices Committee's rules, a *resume* of the London Building Act and much other useful data. Altogether an excellent little book at a small cost, concise in style, and crammed with technical details which should be in the hands of architects, engineers, fire insurance surveyors and all others interested in so vital a subject.

### The Principles of Industrial Economy.

By Robert Walsh, F.C.A., F.S.S. P. S. King and Son, London. 6s. net.

Whether one agrees with the conclusions drawn by the author of this volume or not, there is no doubt that it represents the results of exhaustive research and embodies very valuable information in an easily accessible form on the subject dealt with. He criticises very strongly the iniquitous legislation that has practically placed Trade Unions above the reach of the law. The author does not condemn sound trade unionism, but argues that at the present time they do not exercise their true functions, but act in restraint of trade. In other words, they restrict that freedom of trade which the politicians responsible for the

legislation that has placed the unions in this anomalous position, so earnestly advocate. With regard to our fiscal system, Mr. Walsh urges that we have only been able to maintain our progress in export of merchandise by cutting profits to a ruinous extent, and that our progress in output can only be done with gradually diminishing profits on an increased turnover, and states that the history of several other nations has shown that the adoption of a system of free imports has led to the gradual decay of their industries. Of course, the amount of literature dealing with this subject turned out during the last few years has been enormous, but this volume is written from a practical rather than a theoretical point of view, and may be regarded as a useful addition.

**Engineering of Antiquity and Technical Progress in Arts and Crafts.**

By G. F. Zimmer, A.M.Inst.C.E. Probsthain and Co., London. 1913.

It is seldom that matter of such archæological and engineering interest is so skilfully blended as it is in this little volume. The author deals in a fascinating manner with the early records of engineering, selected from a mass of information obtained by exhaustive research among ancient records at the British Museum and elsewhere. The antiquity of metals is first dealt with, and the author is of opinion that the use of iron preceded bronze. According to Chinese annals, the introduction of iron took place about 2940 B.C.; Biblical records state that Tubal Cain used brass and iron, which would be about 3000 B.C. Herodotus, however, says that iron tools were used by the builders of the Pyramids and the tombs of Memphis, which date back 4,000 years. Gold was probably known and used—then as now for ornamental purposes only—even long before this. An interesting chapter is devoted to the conveying of loads from earliest times, and discusses how the colossal Egyptian statues were transported; the building of the Pyramids is also dealt with. The general principle adopted for moving heavy loads was the application of physical force, huge numbers of people being employed. As to the medium employed, opinions are divided between levers, rocking-cradles and inclined planes, though the first two appear most probable for such work as the building of the Pyramids involved.

The book is very fully illustrated with quaint pictures from old bas-reliefs, &c., and is crowded from cover to cover with interesting matter. We certainly hope that the author will add in another volume, more of the information he has accumulated, but which could not be included in the present volume owing to lack of space.

**A Dictionary of Applied Chemistry.**

Vol. IV. By Sir Edward Thorpe, C.B., LL.D., F.R.S. Messrs. Longmans Green. London, 1913. 45s. net.

# MANUFACTURING NEWS

**Aerial Transport in China.**

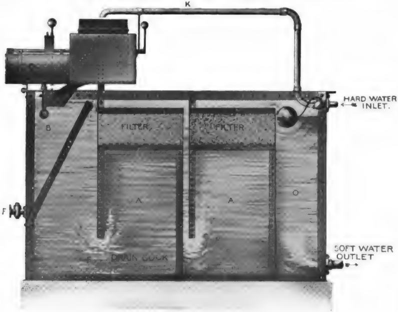
COAL mining operations were carried on even in ancient times in the province of Shansi, in China, the peasants extracting the coal from surface seams and selling it to a transport company. This company has provided the capital, Pekin, with coal from time immemorial, and for this purpose laid out roads from there to the coal district, over which immense caravans of mules and camels conveyed the coal. The traffic on the roads became, however, so dense that the causeways over the river had to be doubled, so that the loaded caravans would not interfere with those returning. These causeways were simply dams piled up, interrupted at places and connected by planking, or sometimes faggots were filled in and weighted with stones and earth, in

VIEW OF THE MOUNTAIN OF THE TEMPLE JOSHAN SHOWING ROPEWAY SUPPORT ON THE SUMMIT. THIS AERIAL LINE IS 15 MILES LONG.

LARGE SPAN OVER VALLEY, NEAR THE TOLI CENTRAL STATION OF THE AERIAL RAILWAY OF THE PEKIN SALT GUILD.

order to allow a passage for the water through the faggots. The Pekin Salt Guild, which effects the transport of the coal, has now installed an extensive wire ropeway plant, on the system of Messrs. Bleichert's Aerial Transporters, Ltd., London. The ropeway commences at Toli railway station and then runs about 6 miles, with an angle station in the middle, to a central station. Here the line divides into two branches. The first branch, 4½ miles in length, runs at an angle to the end station Hung-Mechan; the second, about 5 miles long, having four angle stations, leads to the end station at Chin-Chian-Kon. The entire ropeway plant has a total length of about 15 miles and has, including the end stations, 13 intermediate and loading stations, in which the coal is brought from the individual mines to the wire ropeway. The coal is then carried by the ropeway via the central station to the Toli station, where it is loaded on the railway. The hourly capacity of the line amounts to 50 tons. In the two illustrations views of this remark-

able wire ropeway plant are shown, one showing a part of the Toli central station section with the large span over a broad valley. In the background on the right-hand side, noticeable by a white spot, the line to the central station Chin-Chian-Kon branches off, a cutting having been made in the marble stratum, in order to avoid a deviation in the course of the track. The other shows the Mountain of the Temple Joshan, on the summit of which a support has been placed, which carries the wire ropeway over the consecrated ground of the Temple. This aerial wire ropeway, which reflects great credit on Messrs. Bleichert, is a sign of the times in China—and apart from its engineering interest is indicative of the new spirit that is manifesting itself in this country.




WATER SOFTENING PLANT OF MESSRS. LASSEN AND HJORT, OF LONDON.

### Water Softening Plant

An interesting exhibit at the recent Mining Machinery Exhibition was that of Messrs. Lassen & Hjort, of London, showing one of their rectangular design patent automatic water softening plants in full working order, softening London water from 17° to 2°. The hard water entering alternately fills each side of a double-chambered receiver (see photograph)—which when full overbalances and allows the water to be displaced from the tipper box through the stand pipe into the first compartment of the softener. At each turn of the tipper, a certain amount of chemical re-agent passes through the patent chemical discharge valve fitted to the bottom of the semi-circular chemical container, when it meets the incoming water. The valve in question is very easy of adjustment, so that the amount of chemical re-agent can be altered with the utmost nicety. The water and chemicals meet in the first compartment of the softener where the chemical reaction takes place, and the hardness is deposited in the form of a liquid

sludge on the floor of the tank. The water then passes upwards through the filters and finally into the softened water storage compartment at the end of the plant. A ball-valve operates in the storage compartment, so that when full the supply of hard water to the plant is automatically cut off.

The chemicals used are best fresh burnt lime and soda ash, both purchasable in the open market, and the cost of treatment in the majority of cases is only a fraction of a penny per 1,000 gallons. The filtering material is composed of a special fine-grade wood wool, which can be used over and over again after cleaning, so that the cost on this score is negligible. The attention required by the plant does not exceed half an hour daily, to replenish the chemical container and open the sludge cocks for a minute or two; the filters require cleaning on the average about every eight weeks.

In all cases where a plant of rectangular design is not suitable, a cylindrical plant can be supplied which carries out the process equally well.

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### A New Dynamometer.

We have received details from the Griffin Engineering Co., Ltd., of Bath, of a new dynamometer, which they have recently placed on the market. The apparatus is a modification of the firm's original central expanding armature dynamometer, and while embodying the special points of this type, is specially arranged to adapt it for accurate readings at the highest speeds under all variations of load or torque.

It consists essentially of an enclosed conical ended drum, in the interior of which are two adjustable conical friction discs mounted on a central shaft which is actuated by the motor or other source of power to be tested, the frictional contact between the discs and the corresponding ends of the drum being regulated by an exterior hand wheel in accordance with the load to be measured.

The cooling is effected by a small stream of water which, passing into the drum at the lower part of its periphery, is maintained in constant contact with the frictional surfaces by centrifugal action and discharged opposite the inlet after being swept entirely round the inner surface of the drum. All frictional heat is thus dissipated with the minimum quantity of cooling water, which further acts as an efficient lubricant between the frictional surfaces. The drum is mounted on trunnions which oscillate on ball bearings. Negative resistance is thus practically nil, the whole of the turning energy imparted to the discs being transmitted through a lever (attached to the drum) directly to a dead weight, the reading being given at the spring dial, or, as an alternative arrangement, the pull may be taken direct on the spring without the intervention of the dead weight.

The discs, being in perfect balance with a torsional strain only on the shaft, the entire apparatus remains perfectly steady at all speeds and loads. Shaft connections may be made direct either by means of solid or flexible couplings or through an intermediate cardan or flexible shaft, the latter being specially suitable for the lighter powers and high speeds, as perfect alignment not being necessary, driving connection is easily and expeditiously made.

Anthony George Lyster, who recently resigned his position as engineer-in chief to the Mersey Docks and Harbour Board in order to take up a consulting practice in London, is the President for the current year of the Institute of Civil Engineers. He is still retaining connection with the Trust, however, in the capacity of consulting engineer to the Board. Born at Holyhead in 1852,—his father at that time being the engineer in charge of the work on the Holyhead breakwater—he was educated at Harrow, and Bonn, Germany, and then entered the engineer's department of the Mersey Docks and Harbour Board as a pupil. After this he spent some time in the works of Sir William Armstrong at Elswick, and then returned to Liverpool, where he was engaged on important dock works. It is not only with the great Liverpool docks that Mr. Lyster has been connected, for he was consulted in regard to the dredging of New York Harbour, and he has designed dredgers for use on the Thames and Hooghli. He has also been consulted by the authorities at Port Elizabeth, Shanghai, and numerous other foreign ports as to the construction of harbour works. He is a member of the Consultative Commission of the Suez Canal, a Colonel of the Railway Staff Corps, and an Associate Professor and M.E. of Liverpool University. He has travelled in Egypt and the United States in his professional capacity. He is now a partner in the firm of Sir J. Wolf Barry.

ANTHONY G. LYSTER,
PRESIDENT OF THE INST.C.E.
See reverse side.

# CASSIER'S ENGINEERING MONTHLY

INCORPORATING CASSIER'S MAGAZINE

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## ELECTRIC RAILWAYS

A CRITICAL SURVEY OF A YEAR'S WORKING.

By Owen M. de Munnick, C.E., E.E.

THE demands on overhead construction for electric railroads at high speeds are quite different to those for the ordinary tramcar lines. The increased speed necessitates that the conducting wire be hung almost perfectly level and in a non-rigid manner for each uneven or rigid point jars the contact-bow or trolley-contactor causing it to spark and imparting a trembling motion to it at high speed which results in a series of sparks.

The application of high tension (alternating) current has also made it necessary to apply other means of suspending and insulating the conducting wire.

Different electric railroads running on high voltage, sometimes using alternating current up to 15,000 volts, are now in operation in England, France, Germany, Italy, Switzerland, Norway, Holland and America. Not all these new equipments have proved to be successful and economical, as the train control by alternating current, especially the multiple unit system, has not yet reached a state of perfection and some of the motor types have not proved to be reliable and suitable for such kind of electric energy. Many improvements must still be made before alternating current can successfully, economically and universally be applied to heavy railroad service under all conditions.

A successful method was found in the catenary system, which permits the conducting wire being suspended at short intervals, and in quite a flexible manner. An easy and reliable insulation of the high-tension current could also be obtained by this method.

There are at present a number of different types of catenary systems, each company having its own methods and patents.

One of the simplest combinations is shown by the accompanying photographs. (Figs. 1-3.) A solid steel wire carries the conducting wire at intervals Longer distances between the poles can be allowed than by the ordinary suspension method which affects a saving of a considerable number of poles on long and straight tracks. This construction is specially suitable for inter-urban lines with trolley-contactor running at speeds not exceeding 40 miles an hour. For cars travelling at higher speeds, a bow-contactor is advisable as the trolley-contactor is apt to impart a sideways swing to the system which results in the contact wheel leaving the conducting wire and causing abnormal wear. Very high tension is never applied to suburban railways, so that a special means of insulation has not to

FIG. 1.—SIEMENS SCHUCKERT SIMPLE CATENARY SUSPENSION 6,000 VOLT A.C.
Blankenese Hamburg-Ohlsdorf Line. Cars equipped with bow contactors.

be considered. Many light railways with catenary construction using a voltage ranging from 500 to 2,400 volts D.C. are now operated in America. The latest reports have shown very favourable results.

It is true, that the third-rail conductor is almost the cheapest and simplest manner of supplying and distributing electric energy to the trains, but a private right of way is necessary for such an equipment. It is dan-

FIG. 2.—SIMPLE CATENARY SUSPENSION. 1,200 VOLT D.C.
Three steel car train equipped with bow contactor. Southern Pacific Railroad (Alameda division), California, U.S.A.

gerous in densely populated neighbourhoods with many level crossings. In Europe it is only applied to underground or viaduct-railways with such exceptions as for instance Paris-Versailles or the portions of the under-

FIG. 3.—SIMPLE CATENARY CONSTRUCTION.
Shore Line Electric Railway (Connecticut, U.S.A.).
1,200 volt D.C.

ground railways of the Metropolis which are extended to the outskirts and neighbouring districts (London Metropolitan Railway). In America however, many lines on the level are operated by the third rail even up to 1,200 volts D.C. (Central California Traction Company.) (Figs. 4 and 5.)

For heavy railroad service, more elaborate catenary suspensions have been devised, but up to the present

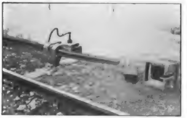


FIG. 4.—THIRD RAIL CONDUCTOR EQUIPMENT WITH SO-CALLED "UNDER RUNNING" SHOE CONTACTOR.
1,200 VOLT D.C.
California Traction Company (California, U.S.A.).

time, none of them can be considered absolutely perfect. The American Westinghouse Company for instance has constructed a catenary system consisting of three carrying wires connected together by triangles on which the conducting wire is hung to the lowest of the three wires by means of clams. (Figs. 6 and 8.) This system is used on the New Haven and Hartford Railway, and is an improvement of the older London, Brighton and South Coast Railway construction, by which the lowest wire was used directly as conducting wire. (Fig. 7.) This construction, however, has not proved to be altogether successful. The enormous weight is certainly a great drawback as cross-girders, anchor-poles, etc., consequently become excessive in dimensions and owing to the increased stress due to wind-pressure on the wires, all these structures must be made strong enough to withstand excessive occa-

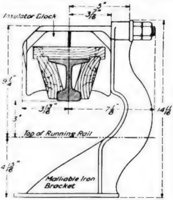



FIG. 5.—UNDER RUNNING THIRD RAIL SYSTEM.
1,200 VOLT D.C.
California Traction Company (California, U.S.A.).

sional strain. The arrangements at crossings and junctions become very complicated and heavy. Exceptional accuracy must be exercised during the construction of the system to prevent distortion of the paraboloid which is formed by the three wires. The great rigidness of this construction is partly eliminated by the clams which carry the conducting wire, but not sufficiently.

A very important point which should be considered in all overhead wiring systems is, that the free outlook from the train must remain unobstructed. Semaphores and other signals should have a proper background to allow quick determination of their posi-

FIG. 6.—WESTINGHOUSE TRIANGLE CATENARY CONSTRUCTION.
New York, New Haven and Hartford Railroad (New Haven section Connecticut, U.S.A.).

FIG. 7.—WESTINGHOUSE TRIANGLE CATENARY SUSPENSION.
London Brighton and South Coast Railway, 6,000 volt A.C. Cars equipped with bow contactors.

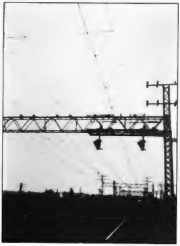


FIG. 8.—WESTINGHOUSE TRIANGLE CATENARY CONSTRUCTION.
New York, New Haven and Hartford Railroad. Semaphores attached to cross girders, difficult to distinguish at a distance.

tion. It will be readily understood that the Westinghouse catenary system does not meet these requirements in every respect, as the enormous intricate structures with their wires, are confusing and liable to prevent the engine driver from distinguishing the signal at a proper distance, specially on gradients and at curves.

On the Harlem River Section of the New Haven Railway, another combination has been tried in which the triangle construction was abandoned. Here each span is intersected by two channel iron cross bars carried by steel cables connected to the cross girders, and and bridges on the poles. The system rests on these bars, thus forming three smaller spans between each pair of poles instead of the single long span from mast to mast, as in the triangle construction. This idea has, however, proved not to answer expectations and a new improvement is on trial at present on the Boston-Providence line, now in course of construction.

It is a well-known fact that change of temperature influences the stress of the wires and consequently also their sa'. If this action of the temperature is not automatically controlled, it will be readily understood that the conducting wire will not hang perfectly level under all weather conditions.

The German firm Siemens, Schuckert Werke in Berlin has a method by which the influence of the temperature on the conducting wire is controlled by means of weights. The conducting wire is divided into sections, about a mile long. At the end weights are connected to this wire, which maintain a constant strain. Expansion and contraction are thus balanced. The other wires (*i.e.*, the parabolical and parallel) are not under control, their sag consequently will increase or decrease according to changes of temperature. This involves some movement of the vertical suspension wires and also of the clams which carry the conducting wire but as the weights are keeping this wire in almost a straight position, little effect is caused by it. A special construction was, of course, necessary at the places where two sections meet and the strain is conducted to the weights hanging alongside the poles. (Fig. 9.)

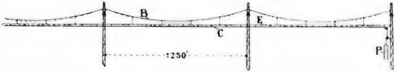



FIG. 9.—SIEMENS SCHUCKERT SYSTEM.
Expansion and contraction of conducting wire C controlled by weights P. Dotted lines show position of parabolical wire B and parallel wire E in hot weather.

Another Berlin firm, the Allgemeine Elektrizitaet Gesellschaft has introduced a system by which all wires are movable and controlled by weights so that all drawbacks due to the influence of temperature are eliminated. An ideal system, in every respect, did

FIG. 10.—S.S.W. CONSTRUCTION.
Rotterdam The Hague, Scheveningen Electric Railway, 10,000 volt A.C. Semaphores visible above cross girders.

FIG. 11.—A.E.G. METHOD.
System constructed alongside of tracks before hoisting in place. Dessau-Bitterfeld Line (Germany). 10,000 volt A.C.

FIG. 12.—A.E.G. CATENARY CONSTRUCTION. HOISTING COMPLETED SYSTEM AND BRINGING ON PLACE OVER TRACK.
Dessau-Bitterfeld Line (Germany). 10,000 volt A.C.

not result though it has many good features.

During a number of years different trials have been made on their experimental railway at Oramienburg near

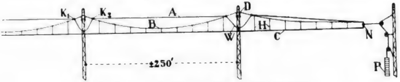



FIG. 13.—ALLGEMEINE ELEKTRIZITAET GESELLSCHAFT CONSTRUCTION.
Expansion and contraction of wires A, B, C, controlled by weights P. System rests and revolves on insulators D. Lever N joins the three wires together near the weights.

Berlin and a system was finally evolved that was adopted by the Prussian State Railway. For trial, in 1910 the line Dessau-Bitterfeld (steam road) was partly equipped with this system (Figs. 11-16), the other part being equipped by the S.S.W. Company after

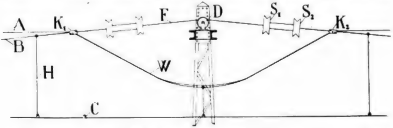



FIG. 14.—A.E.G. CATENARY CONSTRUCTION.
Detail of the support at cross girder. D is the insulator on which system revolves by change of temperature.

their method as already described above. It will be of great importance when the extensions to Magdeburg Leipzig and Halle are made as the distance Dessau Bitterfeld is hardly 27 miles long and too short for making long distance trials at high speeds.

A special feature of this method is that there is no necessity to block the line during construction, as in all other systems. Blocking one line means endangering the traffic, as all trains in both directions have to pass over single' track. How many accidents are liable to occur was proved during the construction of the New Haven roads. The A.E.G. system is constructed on the side of the railroad and brought to its proper place afterwards. At the stations, it is, of course, impossible to complete the catenary work on the side of each track, but as there are generally several tracks at hand, one track can easily be blocked until finished, and the next can be taken up afterwards.

In the accompanying drawings of the A.E.G. system (Figs. 13 and 14), three spans of the overhead line and the method of connecting the weights are shown. A is the strain wire, B parabolical suspension wire, C con-

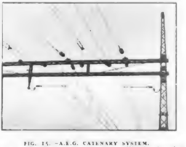


FIG. 15.—A.E.G. CATENARY SYSTEM.
Section end with lever construction. Weights hanging alongside poles. Dessau-Bitterfeld Line. 10,000 volt A.C.

FIG. 16.—A.E.G. CATENARY SYSTEM.
Centre pole with double cross arm construction. Anchor pole is in foreground. Dessau-Bitterfeld Line. 10,000 volt A.C.

ducting wire, H vertical suspension wire, $K_1$ and $K_2$ are clutches, W is the loop formed by the wires A and B passing below the cross girder; F is a flexible wire to which the insulators $S_1$ and $S_2$ are attached. This wire connects the clutch $K_1$ with $K_2$ and transfers the strain from one side to the other, as the loop W is hanging loosely. The flexible wire F is insulated by the insulators $S_1$ and $S_2$, and rests on the insulator D on the cross girder. Galvanised clutches or clams are used to join the wires together where necessary, as no connections are made by soldering.

The insulators are so made that in case one of them breaks the whole system cannot fall, as the two wires are looped inside the insulator. The strain wire A is provided to assure a regular stretch of the parabolical carrying wire over the whole length of a section from one pair of weights to the other pair at the end of the same section. This strain wire, of course, has very little sag. The clutches, $K_1$ and $K_2$, join the strain wire and parabolical suspension wire together at each suspension point on the cross girder, transferring their strain to the flexible wire F. The loop formed under the cross girder by the two first mentioned wires is necessary in case an after-regulation of one of the wires, or even both is needful. By using a pulley system, the weights could be reduced to one-fourth of the total stress required. The working of the system is as follows:—

When the temperature is increasing, the parabolical carrying wire B will expand, thus increasing the sag or in other word decreasing the strain. The strain wire A will expand to about the same extent, being made of the same material (galvanised steel cable). Its strain will also decrease; and, as it has very little sag, its strain will decrease considerably more than that of the parabolical wire. The weights at either end exercise a constant strain, and thus stretch both wires until the stress is balanced, when the drops will be exactly the same as before, since, for a certain constant strain there is

always a certain constant drop or sag. A drop in the temperature causes an opposite action to take place. The same happens to the conducting wire, as it is also connected to the same weights at both ends of each section. Near the connection of the weights is a lever, to which the three wires are joined, and a flexible wire bringing their stresses over to the weights on the masts. This lever is necessary, because the strain wire and parabolical wire are made of steel, while the conducting wire is made of hard bronze.

FIG. 17.—SIMPLE CATENARY CONSTRUCTION, SHOWING CROSS OVER ARRANGEMENT. 1,200 VOLT D.C. Southern Pacific Railroad (Alameda division), California, U.S.A.

These have different temperature co-efficients, which this lever neutralises.

To start the construction of the system small hooks are fixed to the masts at each side of the railroad about seven feet above the ground. On these hooks, which are provided with little wheels, the flexible wire F (already fitted complete with the insulators $S_1$ and $S_2$, with necessary clutches) is laid, and the strain and parabolical wire are connected to this flexible wire, the required drop of both wires being regulated at the same time. This drop can be measured by means of a dynamometer (measuring its strain), but it is easier and sufficiently exact to ascertain it in the following manner:—A small post is erected in the middle between the two masts; three movable hands are fitted to this post. The top one is level with the wheel or hook on the mast, the other two hands giving the theoretical sag of the two wires. When this is done with all the spans which belong to one section, the vertical suspension wires can be fitted on and the conducting wire is hung on these wires (after being stretched on half its normal strain). When the system is ready over one complete section, it

FIG. 18.—S.S.W. CATENARY SYSTEM. Section end masts with current switch off mast in centre. Rotterdam, The Hague, Scheveningen Electric Railway. 10,000 volt A.C.

is pulled up by block and tackle and placed on the insulator in the centre above the track. It will be understood that this pulling up of the catenary work should be done carefully to prevent distortion of the system. When it is brought to its proper place it will be advisable to inspect the line by means of a tower wagon, but this can be done at a time that no train is passing, in order not to interfere with the traffic.

Practice has proved, that through the insulator D, on which the whole system rests, is made revolving, the friction is considerable, specially in curves, where side-strains sometimes prevent a normal revolving of the

FIG. 19.—S.S.W. CATENARY SYSTEM.
Rotterdam, The Hague, Scheveningen Electric Railway. Note lightness of structures and catenary work at cross overs and easiness of distinguishing signals.

supporting devices. An increased stress is consequently necessary to overcome the excessive friction, which results in a temporary distortion of the catenary work and a raising of the conducting wire until the strain is balanced. A difficulty is encountered at stations, where many crossings with short sections and different spans (which means different strains), make a proper balancing by weights unsatisfactory. Short sections are therefore left uncontrolled.

There is a system in Norway by which the cross arms on the poles are made movable. It is very interesting as an experiment, but will hardly find further application. The necessary force to overcome the friction is at times considerable, which means that the increased or decreased stress has

FIG. 20.—SIMPLE CATENARY SYSTEM.
Formerly running by 6,600 volt A.C., now operated by 1,200 volt D.C. Washington, Baltimore and Annapolis Electric Railroad (Washington, U.S.A.).

first to reach a certain point before the system is moved.

It is very difficult to pronounce a certain system the most suitable, but all points considered, we think that the S.S.W. system (Figs. 18 and 19) offers the most advantages at present, though it has the drawback, that track blocking is necessary during construction. This system would be greatly improved if a parabolical—and parallel wire entirely made of an alloy of aluminium were provided, as the temperature co-efficient of this metal is so small that no noticeable influence will occur by change of temperature. Another great merit of aluminium is its lightness, which would require very light structures to carry the system. Owing to the great cost of the material and construction of such wires, no line has been built yet in this manner.

Many railway companies have electrified a small part of their line for trial purposes. A great many of the existing steam roads, however, are not concerned with the question of electrification, as steam power will in many instances prove to be a cheaper source of power. But when electricity can economically be applied to main lines, a great difficulty will be encountered in establishing a through-train service if no conformity in system is obtained. This fact has already proved a serious drawback in America. The New York Central Railway, for instance, has adopted the third-rail system and direct current of 600 volts. The Newhaven and Hartford Railway (Figs. 6 and 8) employs alternating current conducted by overhead wiring. As both roads are using the same terminal station at 42nd Street, New York, it became necessary for the New Haven Road to have their locomotives built to suit both systems.

A double system always implies, of course, a more intricate train-controlling system, or may even be in certain circumstances quite impossible. High initial cost and expensive upkeep are consequently the result. In Toledo (Ohio), and many other American cities, the same difficulty arises in the suburban light railways using different current and voltage, so that through service becomes difficult and unsatisfactory. It is to be hoped that in the future, both in America and Europe, some attempt will be made to adopt a uniform system as far as this is possible, so that successful co-operation in handling traffic may become practicable.

The Washington, Baltimore and Annapolis Electric Railway has had its equipment for 6,600 volt alternating current re-constructed into a system for 1,200 direct current (Fig. 20). This change was made owing to the fact that no through service into the centre of Washington was possible, as all city lines are running by direct current ; and further, on account of the car weight being over 40 tons, which is the limit of weight for every electric car going through the streets. Another factor that greatly influenced the decision to reconstruct was the enormously high running costs of the old system. Since 1910, when the change was made, a more satisfactory operation has been obtained and a saving of 40 per cent. in the railway company's power bill effected.

This fact is really striking and apt to imply that only direct current gives a successful operation. In certain instances this is true and at the present time in a great number of cases, direct current gives a lower running cost than alternating current, but we must take into consideration the fact that alternating current for practical traction purposes, was only adopted at the beginning of this century, and a state of perfectoin cannot be attained in so short a time. It is the opinion of the writer that when improvements are made in the application of alternating current and a cheaper operation is possible. it will be *the* future current for heavy railway service at high speeds and very long distances.

# TRAMWAYS OF THE UNITED KINGDOM

## A CRITICAL SURVEY OF A YEAR'S WORKING.

By A. J. Lawson, M.Inst.C.E.

THE following review deals chiefly with the position of the tramways of the United Kingdom as set out in the Board of Trade Return of Tramways and Light Railways on Streets and Roads down to the 31st day of December, 1911, in respect of companies and the 31st day of March, 1912, in respect of Local Authorities; but some of the results for the year 1911 and 1912-13 where these are now available, are made use of for purposes of comparison of progress or retrogression.

### CAPITAL EXPENDITURE.

By the dates first above mentioned municipalities and companies had expended, since the Bristol Tramways and Carriage Company and the Dublin United Tramways Company had first taken up the electrification of tramways on a commercial scale in 1895 and 1896 (Leeds and Dover Muncipalities following suit in 1897) on the purchase and conversion of the old horse and steam tramways and the construction and equipment of new lines, no less than £77,377,390, of which £58,051,093 had been raised by loans and debentures, and £18,011,093 by shares.

Eleven millions of the loan capital had been repaid or otherwise provided for; but, Shade of Hans Breitmann! Where is that share capital now?

### COST OF CONSTRUCTION AND EQUIPMENT.

The total length of the lines on which this huge capital had been expended was only 2,637.05 route miles, of which 1,660.75 were double and 976.3 single track—the total equivalent length of single track line being 4,297.8 miles—and in addition, 5.2 miles of road were being worked by trackless-trolley cars, those crosses between tram-cars and motor omnibuses which retain none of the best points of either parent.

The capital cost per route mile, including all items, was thus £28,766, or £18,005 per track mile, varying between such extremes as £207,836 for the *one-quarter mile* within the City of London at Blackfriars, the £87,590 average of the London County Council lines £67,192 of the London United Tramways Company (for what are practically inter-urban tramways), and the £10,755 per route mile of capital expenditure on the Halifax Corporation lines.

The Edinburgh Cable tramways cost £60,496 per route mile, while the whole of the lines worked by the Glasgow Corporation cost only £35,000 per route mile, including the outlay on an excellent power house.

The Belfast Corporation lines which take their supply of energy from the Corporation's Lighting Station, and therefore had not to bear the expense of a separate generating station for the tramways only, cost £29,741 per route mile, while the Dublin United Tramways Company's lines, with a generating station for the supply of the tramways only, cost £37,402 per route mile.

The average cost per route mile of the 27 principal provincial tramways was £29,710, or (excluding the abnormal Edinburgh lines), £28,903 per route mile for electric tramways.

The average cost of the lines in Greater London (excluding the County Council and London United Tramways, whose cost was abnormal), was almost exactly £40,000 per route mile; but

if we take only the outside tramways owned by the South Metropolitan Company and the ten Local Authorities, other than the County Council (again omitting the exceedingly high cost of the Metropolitan Electric and Middlesex County Council tramways at £61,714 per route mile) the locally owned tramways of greater London represent a capital expenditure of £26,970 per route mile only.

The capital expenditure at the four principal seaside holiday resorts averaged £25,169 per route mile, and on the seven interurban lines £23,442 per route mile, the lowest cost in the latter class being £18,960 per route mile on the Lanarkshire Company's lines, including the cost of a generating station.

CAR MILES RUN AND PASSENGERS CARRIED.

On the whole of the tramways the number of car-miles run by the 12,435 electric and the 309 non-electric cars in stock at the end of the twelvemonths was 323,354,389, carrying 3,127,318,732 passengers, and giving an average of 9.67 persons per car mile. The number of route miles worked electrically was 2,517.77; by cable 25.56 miles; 46 miles by locomotives and 47.7 miles by animal traction, of which, strange to say, 10¼ miles, worked by horses, were owned by the London County Council.

The maxima were:—

| | Route Miles worked. | Car miles run. | Passengers carried. |
|---|---|---|---|
| London County Council .. .. .. | 141.23 | 50,457,812 | 533,440,236 |
| Glasgow Corporation .. .. .. .. | 102.97 | 22,435,076 | 275,610,385 |
| Manchester Corporation .. .. .. | 99.60 | 18,076,999 | 174,424,237 |
| Liverpool Corporation .. .. .. | 67.16 | 12,399,469 | 128,625,374 |
| Birmingham Corporation .. .. .. | 52.15 | 9,697,330 | 113,475,399 |
| Sheffield Corporation .. .. .. | 39.52 | 7,720,006 | 90,458,861 |

DENSITY OF TRAFFIC AND FREQUENCY OF SERVICE.

The greater the density of traffic along a tramway route the more frequent must be the service, always having regard to the necessity of a sufficient load per car mile to provide from the average passenger fares an adequate amount to pay the costs of running and to cover all standing charges, including interest and sinking fund, or repayment, charges for capital borrowed on loans, or in the case of companies, to pay a reasonable rate of interest and ample reserves for depreciation, having in view the terminable tenure of the rights.

A service, therefore, which does not provide over 10d. per car mile in London and 9d. per car mile in the provinces is either too frequent or the traffic density is insufficient, or the fares are too low; and a tramway which will not support a ten minutes' service should never have been constructed. The following were the places with the most frequent services and the densest traffics:—

| | Car Miles per Route Mile. | Passengers per Route Mile. |
|---|---|---|
| London (County Council) .. | 357,800 | 3,777,000 |
| Hull .. .. | 269,751 | 2,919,798 |
| Glasgow .. | 217,880 | 2,676,608 |
| West Ham .. | 211,300 | 2,636,000 |
| Edinburgh .. | 265,529 | 2,501,702 |
| East Ham .. | 168,350 | 2,341,000 |
| Sheffield .. | 195,345 | 2,288,938 |
| Birmingham .. | 185,968 | 2,175,942 |

all the others being well under 2 million passengers per route mile, and in some cases, as the following, most miserably inadequate.

| | Car Miles per Route Mile. | Passengers per Route Mile. |
|---|---|---|
| Dartford .. | 44,200 | 271,000 |
| Erith .. | 66,800 | 584,000 |

Barking, with a car mileage of 81,030 per route mile, and 1,124,000 passengers on each of its 2·84 route miles of lines, throws away all the advantages of 13.87 passengers per car mile by charging such low fares as give an average of ·495d. per passenger only, or about an eighth of a penny per passenger *less than the actual cost of working* the tramways, so that the ratepayers have actually to pay ·413d. for each person carried in an endeavour to *create* a paying traffic in a sparsely

populated district by the extraordinary expedient of charging one-half the cost to the passenger and the other half to the householder. On one of the Midland tramways, the attainment of the same object was sought by acquiring the largest disused colliery spoil-bank in the country on which to construct a garden suburb for housing the chainmakers of Cradley Heath, but traffic did not result from the experiment. As well try to raise hay crops by salting cinder paths.

The London United Tramways Company, with a car mileage of 170,000 per route mile and 1,130,000 passengers per mile over its 55¼ miles of route also failed to cover all charges even out of its average fare of 1·29d. per passenger with 6·751 passengers per car mile, while the Metropolitan Electric Tramways, to save passengers from travelling by motor omnibuses (of which they have now become proprietors), overdid the car mileage per route mile by raising it from 180,000 in 1911, to 212,635 in 1912, for the sake of 1,600,018 additional passengers, making the number 1,627,000 per mile of route worked, but reducing the average number per car-mile from 8·62 to 7·97, and producing, at the average fare of 1·208d. as against 1·23d. in 1911, exactly the same total net revenue from passengers of £460,544, but at the additional cost of working of £24,348 10s. 11d.

The London County Council car mileage was also increased in 1912-13 by 3,485,292 miles, at an additional cost of £90,208; but, instead of carrying more passengers, the number fell below those of the previous year by 20,787,582, and the average fare dropping from 1.031d. to 1.020d., there was a decrease in total revenue of £114,399, compared with the previous year. Additional charges for interest, sinking fund and income-tax amounted to £38,419, against which a small credit of £332 remains out of rents of surplus property and interest on deposits, after payment of Parliamentary expenses, deficit on housing property and interest on purchase money. Taking all these into account, the result of the year's working was a deficit of £19,500 instead of a profit (after payment of all charges) of £497, as stated, as is shown in the item, "Total charges £762,491 less tax deducted and retained from interest on debt £19,988," which retention will have to be made good in the current year. The additional car-mileage in this case was therefore a very costly and useless experiment.

Among the provincial tramways with large total traffics, Halifax, with 56,223 car miles per mile of route, 501,322 passengers per route mile and 8·917 passengers per car mile, made a profit of .19d. per passenger with the highest average passenger fare of 1.264d. charged by any Corporation tramway in the United Kingdom. In this matter of high fares Salford takes second place among the municipalities with an average fare of 1.251d. per passenger.

REVENUE.

The revenue from passengers of all tramways for the twelve months amounted to £14,061,220, and the further receipts from advertising, &c., were £664,848, making the total income from all sources £14,726,068, from which sum had to be deducted the working costs of £8,924,420, or 60.6 per cent. of the gross receipts, leaving a balance of net revenue of £5,801,648, or 7½ per cent. on the capital expended.

The largest revenue producing undertakings were :—

| | |
|---|---|
| London County Council Tramways .. .. | £2,366,128 |
| Glasgow .. .. .. | 1,040,847 |
| Manchester .. .. | 856,789 |
| Liverpool .. .. .. | 614,079 |
| The Metropolitan Electric Company .. .. | 470,167 |
| Birmingham .. .. | 440,100 |
| Leeds .. .. .. .. | 393,812 |
| London United Electric Tramways Company .. | 343,987 |
| Sheffield .. .. .. .. | 341,418 |
| Dublin United Tramways Company .. .. | 321,307 |
| Edinburgh Tramways Company .. .. .. | 292,477 |

The Bristol Tramways and Carriage Company show total receipts of £335,738, but, as about £100,000 of

that amount is from other sources than the tramways, *in order of tramways* they come even after Salford, which is the last of the municipal tramway undertakings having receipts of over a quarter-of-a-million per annum with a total of £259,190.

REVENUE PER ROUTE MILE.

It may seem surprising that with such huge revenues there should be only five tramway undertakings in the United Kingdom with a total revenue of over £10,000 per route mile, but such is the case. These are :—

| | Per route mile. |
|---|---|
| London County Council Tramways .. .. | £16,754 |
| Edinburgh Tramways .. | 11,694 |
| Hull Corporation Tramways | 10,730 |
| Liverpool Corporation Tramways .. .. .. | 10,111 |
| Glasgow Corporation Tramways .. .. .. | 10,108 |

The poorest results were obtained by :—

| | Per route mile. |
|---|---|
| Sheerness Tramways Co. | £1,114 |
| Wrexham ,, ,, | 1,258 |
| Peterborough ,, ,, | 1,316 |
| Taunton ,, ,, | 1,463 |
| Dartford Urban District Council .. .. .. | 1,601 |
| South Lancashire Tramways Company .. .. | 1,861 |
| Barking Urban District Council .. .. .. | 2,408 |
| Yorkshire Woollen District Corporation .. .. | 2,479 |
| Erith Urban District Council | 2,839 |
| Halifax Corporation .. | 2,724 |
| Hastings Tramways Co. .. | 2,973 |
| Bexley Urban District Council .. .. .. | 3,001 |

APPROPRIATIONS.

Under this heading the amounts dealt with should be the net earnings (or losses) on the working of the tramways for the year, but although this is the case in over ninety per cent. of the undertakings, it is not so with some of the Corporation accounts in which are included amounts unappropriated in former years (which are treated as amounts brought in as in Companies' accounts), and in two most conspicuous cases profits which have nothing to do with tramway working have been brought in to swell the gross and net revenues, viz. :—the Bristol Tramways and Carriage Company where about £100,000 is thus dealt with, and the Birmingham and Midlands Tramways' Company which brings into its accounts profits from financial operations which had nothing to do with tramway earnings, but was thus able to pay a large dividend from extraneous sources and make other appropriations out of the £44,000 thus dealt with. The object of the return, which was to secure accurate information as to the cost of installation of tramways, and of their working is thus vitiated. The amount dealt with is also complicated with allocation of the amounts taken from the rates to make up the deficiencies of badly managed concerns which cannot make both ends meet out of their traffics. There were also several small tramways throughout England in which not only were there no payments made on account of interest or sinking fund charges, but in which even the losses on actual working were not provided for, the evil day being deferred to a future occasion.

Appropriations amounting to £94,334 other than the total net revenue given in the return are made up to this by £32,202 brought forward and £62,132 aid from rates.

The allocations were :—

| | £ |
|---|---|
| Interest or dividends .. | 2,079,836 |
| Repayment of debt or sinking fund .. .. | 1,283,394 |
| Rent of leased lines, &c. .. | 451,087 |
| Reserve for depreciation and renewals .. .. .. | 1,266,681 |
| *Relief of rates .. .. | 541,577 |
| Aid from rates .. .. | 62,132 |
| Income tax and other matters .. .. .. | 326,975 |

*Including payments to "Common Good" by Dundee and Glasgow.

The repayments of loans and contributions to sinking funds to the end of the financial year 1911-12 appear to

have been in round figures, £11,000,000, and the total appropriations to reserve for depreciation and renewals, £4,641,000.

### Aid From Rates.

This form of legalised burglary, according to the official return, was resorted to in 28 cases. The first two columns in the following table make up the total sum required to pay working costs, interest on borrowed capital, sinking fund charges thereon and the meagre pittances set aside in some cases for depreciation and renewals.

| | Gross Revenue | Aid from Rates. | Average Fare. |
|---|---|---|---|
| | £ | £ | £ |
| Barking .. .. | 6,838 | 5,242 | .495 |
| Burton-on-Trent .. | 16,166 | 250 | .832 |
| Colchester .. .. | 10,735 | 1,693 | 1.349 |
| Darlington .. .. | 11,874 | 1,018 | .751 |
| Erith .. .. | 13,370 | 2,989 | 1.051 |
| Glamorgan .. .. | 469 | 218 | .500 |
| Gloucester .. .. | 17,002 | 2,316 | .928 |
| Haslingden .. .. | 7,929 | 400 | 1.451 |
| Heywood .. .. | 11,549 | 1,218 | 1.235 |
| Ilkeston .. .. | 6,689 | 2,613 | 1.385 |
| Ipswich .. .. | 22,939 | 4,292 | .996 |
| Kilmarnock .. .. | 8,638 | 2,180 | .914 |
| Lancaster .. .. | 5,802 | 2,379 | 1.069 |
| Leith .. .. .. | 34,693 | 2,000 | .870 |
| Lowestoft .. .. | 11,973 | 1,340 | 1.058 |
| Maidstone .. .. | 9,797 | 1,609 | 1.062 |
| Perth .. .. .. | 9,393 | 1,864 | 1.158 |
| Pontypridd .. .. | 23,172 | 6,201 | .585 |
| Rawtenstall and Bacup .. | 25,243 | 1,500 | 1.237 |
| Stalybridge, Hyde, Mossley and Dukinfield .. | 39,563 | 6,472 | .868 |
| Swindon .. .. | 8,664 | 1,848 | .867 |
| Wigan .. .. .. | 67,570 | 12,500 | 1.306 |

It is obvious also that where traffics are light revenue must be small whatever the fare, as at Colchester with 1,828,878 passengers; Haslingden, 1,252,757; Ilkeston, 1,732,846; Lancaster, 1,473,987; Perth, 1,831,147; and Maidstone, 2,096,458 passengers. In all of these places an average fare of 1¼d. per passenger would have saved appealing to the rates for help, while places with traffics of from 2 to 2½ millions apparently require a 1¼d. average fare to cover all costs and capital charges.

### Relief of Rates.

On the other hand, not less than £541,577 were handed over by 42 municipalities and other local authorities from the profits of working their tramways for the relief of rates, or, as it is euphemistically called in Dundee and Glasgow, "For the Common Good." Thus the passengers' pill is gilded!

The most successful operators in this highwayman's policy of robbing the passenger were:—

| | Amount applied in Relief of Rates. | Average Fare per passenger. |
|---|---|---|
| | £ | d. |
| Birmingham .. .. | 46,046 | .915 |
| •Belfast .. .. .. | 32,833 | 1.053 |
| Bolton .. .. .. | 10,500 | 1.074 |
| Bradford .. .. | 22,000 | 1.169 |
| •Glasgow .. .. | 52,068 | .860 |
| •Hull .. .. .. | 12,000 | .879 |
| •Leeds .. .. .. | 61,163 | 1.093 |
| Liverpool .. .. | 38,244 | 1.122 |
| Manchester .. .. | 85,000 | 1.163 |
| •Newcastle-on-Tyne .. | 13,442 | 1.045 |
| Nottingham .. .. | 18,000 | 1.067 |
| Salford .. .. .. | 18,000 | 1.251 |
| •Sheffield .. .. | 26,889 | .896 |

and the other 29 road agents whose "appropriations" in bulk were not so large were:—

| | | |
|---|---|---|
| | £ | d. |
| Ashton-under-Lyne .. | 1,350 | 1.077 |
| Ayr .. .. .. | 1,249 | .968 |
| Blackpool .. .. | 5,000 | 1.493 |
| Burnley .. .. | 7,300 | 1.185 |
| Bury .. .. .. | 4,414 | 1.086 |
| •Cardiff .. .. | 4,650 | 1.094 |
| Croydon .. .. | 8,000 | 1.065 |
| Dundee .. .. | 1,000 | .861 |
| Erdington .. .. | 2,813 | .915 |
| Halifax .. .. .. | 4,807 | 1.264 |
| •Huddersfield .. .. | 6,481 | 1.190 |
| Kings Norton .. .. | 3,022 | .915 |
| •Leicester .. .. | 8,000 | .999 |
| Leyton .. .. .. | 1,543 | .674 |
| Morecambe .. .. | 1,000 | 1.182 |
| Nelson .. .. .. | 999 | 1.185 |
| •Northampton .. .. | 2,000 | .986 |
| Plymouth .. .. | 3,027 | 1.027 |
| •Portsmouth .. .. | 4,000 | 1.062 |
| •Reading .. .. .. | 1,860 | .951 |
| Rotherham .. .. | 750 | 1.097 |
| Southampton .. .. | 5,000 | 1.256 |
| Southend .. .. | 1,000 | 1.091 |
| Stockport .. .. | 9,000 | 1.341 |
| Sunderland .. .. | 5,000 | .971 |
| Wallasey .. .. | 6,000 | 1.201 |
| Warrington .. .. | 1,500 | .907 |
| Wolverhampton .. | 3,777 | 1.091 |
| York .. .. .. .. | 850 | 1.077 |

• Places marked thus have their own generating stations or Power Houses.

In this connection the *reductio ad absurdum* has been achieved by Birmingham, which, out of the large revenue of £574,248 for 1912-13 from high passenger fares made a net profit, after payment of all capital charges and working costs, and placing to reserve £45,000, of £56,000, all of which has been handed over for the relief of the rates, *because* the Gas Department, owing to the competition of the Electrical Department (which had received a high price for the power supplied to the Tramways Department) was unable to make its usual contribution for the relief of the rates of such householders as use electricity only in their houses or places of business. This is indeed a case of the snake making itself into a hoop by swallowing its tail!

EXCESSIVE COST OF POWER.

But these contributions to the "common good" are not the only ones for which the wherewithal is provided from the passenger fares, for in the unstarred towns the supply of energy for the tramways is taken from the generating stations originally constructed for the purpose of supplying current for electric lighting and motive power for manufacturing, and the excess charge to the tramways, after making due provision for interest and sinking fund charges on the capital cost of the plant set apart for tramway use, goes in reduction of the price of current for lighting and supply of power to other consumers. This is notably the case in the places given in table No. 1.

The total possible yearly saving in cost of energy for the tramways of these 15 places alone is thus £312,530, and that the figure set opposite each, giving the possible cost of production in a power house devoted exclusively to the supply of the tramways is within safe limits, is proved by the results of the Smethwick power house, designed by the writer for lighting, power and traction purposes, where the inclusive costs are well below the possible figure set opposite Birmingham, and by the figures of the tramways undertakings owning their own power houses, as set forth in table No. 2, giving the actual units supplied to the tramways and the actual cost. Of course it must be understood that an allowance has to be made for interest and sinking fund

TABLE I.

| | Units used on Tramways. | Price per Unit. d. | Practicable Cost. d. | Excess charge p. Unit. d. | Possible annual saving. £ |
|---|---|---|---|---|---|
| Birmingham .. .. .. | 19,460,219 | .933 | .400 | .533 | 43,218 |
| Bolton .. .. .. | 4,468,961 | 1.100 | .600 | .510 | 9,497 |
| Bradford .. .. .. | 10,539,539 | 1.000 | .500 | .500 | 21,958 |
| Burnley .. .. .. | 2,855,006 | 1.239 | .700 | .539 | 6,412 |
| Bury .. .. .. .. | 2,085,636 | .936 | .720 | .215 | 1,868 |
| Croydon .. .. .. | 2,287,566 | 1.670 | .900 | .770 | 7,339 |
| Halifax .. .. .. | 3,593,358 | 1.133 | .533 | .600 | 8,984 |
| Liverpool .. .. .. | 23,867,230 | 1.047 | .410 | .637 | 63,348 |
| Manchester .. .. .. | 29,890,427 | 1.023 | .400 | .623 | 77,715 |
| Nottingham .. .. | 6,039,203 | 1.250 | .500 | .750 | 9,186 |
| Oldham .. .. .. | 3,541,360 | 1.497 | .597 | .900 | 13,230 |
| Salford .. .. .. | 9,137,678 | 1.239 | .439 | .800 | 30,459 |
| Sunderland .. .. .. | 1,749,224 | 1.476 | .660 | .826 | 6,020 |
| Southampton .. .. | 1,874,217 | 1.690 | .750 | .775 | 6,052 |
| Wallasey .. .. .. | 1,929,122 | 1.615 | .720 | .895 | 7,194 |

TABLE II.

| | | | |
|---|---|---|---|
| Belfast .. .. .. .. .. | 9,023,584 units | .537d. per unit. | £20,190 total. |
| Cardiff.. .. .. .. .. | 3,935,945 .. | .416d. .. .. | 6,828 .. |
| Dublin.. .. .. .. .. | 12,175,946 .. | .379d. .. .. | 19,252 .. |
| Glasgow .. .. .. .. | 33,838,191 .. | .318d. .. .. | 14,866 .. |
| Huddersfield .. .. .. | 5,120,215 .. | .426d. .. .. | 9,096 .. |
| Hull .. .. .. .. .. | 4,726,903 .. | .583d. .. .. | 11,491 .. |
| Leeds .. .. .. .. .. | 17,235,372 .. | .347d. .. .. | 24,914 .. |
| Leicester .. .. .. .. | 9,248,650 .. | .335d. .. .. | 12,918 .. |
| Newcastle-on-Tyne .. .. .. | 10,703,148 .. | .228d. .. .. | 10,176 .. |
| Northampton .. .. .. | 1,032,199 .. | .813d. .. .. | 3,496 .. |
| Portsmouth .. .. .. .. | 2,583,580 .. | .402d. .. .. | 4,482 .. |
| Reading .. .. .. .. | 955,400 .. | .815d. .. .. | 3,246 .. |
| Sheffield .. .. .. .. | 15,603,810 .. | .288d. .. .. | 18,697 .. |

TABLE III.

| | | | | |
|---|---|---|---|---|
| Birmingham .. .. .. .. .. | £75,646 | for | 19,460,219 | B.o.T. Units 0.933d. |
| Bradford .. .. .. .. .. | 43,898 | .. | 10,539,539 | .. 1.000d. |
| Liverpool .. .. .. .. .. | 104,135 | .. | 23,867,230 | .. 1.047d. |
| Manchester .. .. .. .. .. | 127,388 | .. | 29,890,427 | .. 1.023d. |
| Nottingham .. .. .. .. .. | 31,454 | .. | 6,039,203 | .. 1.250d. |
| Salford .. .. .. .. .. | 47,166 | .. | 9,137,678 | .. 1.239d. |

charges for the plant used for the tramway supply.

Stockport is able to purchase the electrical energy for the tramways it operates of 1,704,943 units at .673d. per unit, paying only £4,781 for the year's supply.

The Belfast station is owned in partnership with the Lighting Department, and the results in economy of cost of production are very good, considering the price of fuel and other circumstances, though Dublin easily surpasses it in cheapness of production. The Potteries Tramways Co. produce 4,150,783 units for £6,692, or .393d. per unit.

Compare with the above the sums paid by towns in table No. 3.

AVERAGE TOTAL WORKING COSTS.

The average total working costs came to 6.623d. per car mile; interest paid to 1.544d. per car mile; repayment of loans to .953d. per car mile; rent of leased lines, .334d. per car mile; making the total cost, including interest and sinking fund charges (the rent of leased lines being divisible into the first two), 9.454d. per car mile on the average throughout the United Kingdom, or, adding the equivalent of the amount set apart for depreciation and renewals, .940d. per square mile, each car ought to produce for every mile run, 10.394d.

INCLUSIVE CAR MILE EXPENSES.

The car mileage costs on this basis will, of course, vary with cheapness of construction or running, and other causes, and in 27 principal Provincial undertakings would be covered by an average income of 9.32d. per car mile, and on the seven large inter-urban lines by an average of 9.57d. per car mile; but London, with a heavier capital expenditure and a slightly higher figure of working costs, requires an income of 10.644d. per car mile to cover all charges. Barking required 12¾d. per car mile, while its income from all sources is only 7¼d., the ratepayers, as already stated, supplying the balance, and even Bexley, with its high average fare of 1.558d. per passenger, only produces 12.633d. per car mile, while requiring 13.276d. to cover all charges, the balance being made up from advertising, etc. Ilford, too, with an average of .842d. per passenger, falls short of covering all charges by nearly 1d. per car mile from fares; and the London United Tramways (despite lower working costs of 5.674d—the lowest in the London area, and only excelled in economic working in six other places in the provinces) owing to the poor traffic of 6.751 passengers per car mile at an average fare of 1,290d. yielding only 8,707d. in receipts—fails to make good the 10.802d. per car mile which would be necessary to cover 5 per cent. on its excessive capital, or nearly four millions sterling, and working costs and depreciation.

East Ham, Leyton, Walthamstow, and West Ham made good out of passenger fares all costs and capital charges, though the margin on their low fares were slender, as did also the South Metropolitan and Metropolitan Electric Tramways Companies on their much higher average fares of 1.440d. and 1.230d. per passenger, the margin of profit on the latter fare disappearing, however, in the results of the following year (1912) and becoming, instead of a positive, a negative quantity.

In the working of the Provincial stations dealing with heavy traffic, Oldham is the only place where the passenger fares fail to cover all charges and to provide a reserve for depreciation and renewals, for which no less than 13d. per car mile would be necessary. But then no place but Oldham pays almost 2¾d. per car mile for power, in which it is only approached by Burnley's more than 2¼d. for electrical energy, these towns having working costs of 8.797d. and 7.896d. per car mile respectively, as against the average of the 27 large provincial undertakings (themselves included) of 6.514d. per car mile.

The other places discredited with excessive workings costs are:—

| | | |
|---|---|---|
| Liverpool | .. | 7.718d. per car mile. |
| Bradford | .. | 7.617d. ,, ,, |
| Halifax | .. | 7.178d. ,, ,, |
| Nottingham | .. | 7.169d. ,, ,, |
| Dundee | .. | 7.077d. ,, ,, |
| Manchester | .. | 7.037d. ,, ,, |

The places in which the lowest working costs were attained were:—

| | | Working Costs Receipts per Car Mile. |
|---|---|---|
| Lanarkshire | .. .. | 5.218d. |
| Bury | .. .. | 5.258d. |
| Edinburgh (Cable) | .. | 5.277d. |
| Gateshead | .. .. | 5.416d. |
| Dublin | .. .. | 5.435d. |
| Belfast | .. .. | 5.473d. |
| Hastings | .. .. | 5.490d. |
| Leicester | .. .. | 5.598d. |
| Portsmouth | .. .. | 5.649d. |
| Aberdeen | .. | 5.983d. |

These undertakings with the lowest costs, with the exception of Bury and Belfast, are all owned by companies.

With the exception of these high and low costs tramways all the others vary from 6d. to 6·6d. only per car mile in the working expenses.

It is, therefore, quite evident that working costs not exceeding 6d. per car mile are attainable on any fairly large system, except possibly with such heavy cars as are in use on the London County Council tramways, where the costs could quite possibly be reduced from their present figure of 6¾d. to 6¼d. per car mile.

WASTE OF POWER.

What would have been said in the days of horse traction on tramways if, after purchase of the best procurable hay at the lowest market price, that hay had been used both for feeding the horses and for littering their stalls? Yet practically the same kind of waste is being practised on electric tramways where electrical energy is being painstakingly produced in separate power houses at the lowest possible cost, and is being squandered in reckless use on the cars, or in the car sheds.

In some cases the consumption of power is increased by the employment of heavy eight-wheeled cars on hilly routes on which only four-wheeled cars ought to be run; by frequent stops and starts of cars with any kind of truck owing to interruption from other traffic on the roads; the use of trucks of too long a wheel base on lines with sharp curves, on which the use of so-called "radial trucks" too often produces rail planing instead of easy motion round the curves; and also a habit which many tramcar drivers have of keeping the brakes against the wheels on clear runs with the sole idea of being able to apply the full braking effect with the least possible per onal effort. Anybody who knows about motor driving can observe this last-mentioned cause any day on some of the London County Council cars, on which the average consumption is 2.424 units per car mile, comparing, however, favourably with an average consumption of 2.531 units per car mile for the much lighter four-wheeled cars of the Leicester tramways on more easily worked lines on which the maximum gradient is the same as on the London lines, with the advantage of speed in favour of the London cars.

The heavy, double-decked, bogie cars of the Metropolitan Electric Tramways Company only take 1.556 units per car mile on roads with similar gradients, while the London United Electric Company's cars take 1.788 units. The Croydon Corporation four-wheeled cars of smaller carrying capacity take only .963 unit, which is a very creditable performance, and a record n economical driving which is not approached by any other of the large undertakings, though on the small lines at Peterborough and Southport the companies' cars are run on their practically level tracks at an expenditure of energy of ·67 of a unit per car mile, and at Gloucester .81 unit per car mile is found sufficient.

The seven undertakings outside London, which are the most wasteful in the use of power, are all owned by Corporations, two of which (Burnley and Birmingham) purchase current from their Lighting Departments, while the other five own their own power houses. The following is the list:—

| | Units per Car Mile. | Cost per Unit. d. | Cost per Car Mile. d. |
|---|---|---|---|
| Leicester .. .. | 2.531 | .335 | .848 |
| Newcastle-on-Tyne .. | 2.330 | .288 | .672 |
| Huddersfield .. .. | 2.280 | .426 | .972 |
| Sheffield .. .. | 2.406 | .288 | .581 |
| Burnley .. .. .. | 2.062 | 1.239 | 2.556 |
| Leeds .. .. .. | 2.304 | .347 | .799 |
| Birmingham .. .. | 2.007 | .933 | 1.872 |

On many of the tramways of the

United Kingdom a considerable saving in the use of power has been produced by the installation of meters on the cars, and it would be interesting to know to what extent such appliances are in use on the above-named and other lines.

country is shown in the annexed diagram, the shaded portion of the lines representing the car mileage per car owned in the places named on the left hand, and the shaded and unshaded lines combined the car mileage of cars owned by the places named on

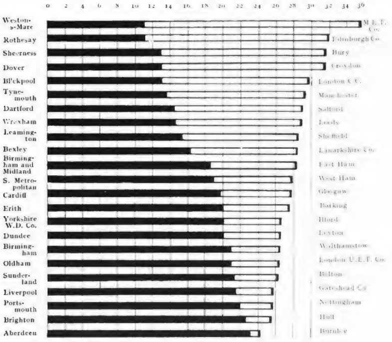



DIAGRAM SHOWING DISTANCE IN THOUSANDS OF MILES RUN PER CAR IN STOCK IN 1911.

KEEP THE WHEELS TURNING is one of the injunctions of responsible managers of tramways in the United States, and one which is very generally followed in all successful undertakings. How far the rule is followed in this

the right hand, the unshaded portion thus representing the difference between the practice of the opposite undertakings. The diagram speaks for itself: there is no need to point out its significance.

# THE LARGEST WATERWORK OF THE WORLD

## THE SUPPLY UNDERTAKING IN SOUTH ITALY

By Gennaro Fattorini, Civ.Eng., A.M.V.D.I.

THE following article is descriptive of an undertaking, now approaching its completion, which may well be regarded as a triumph of modern hydraulic engineering, for the audacity of its conception and the magnitude of its proportions.

Up till the present the Pouille, a district of Italy, comprising one twentieth part of the whole of the country and having a population numbering 2,000,000, was dependent on rain water for its supply, as the springs in that district are very scarce, and an old aqueduct built by the Romans could supply the wants of a only very limited number of people. The tanks, in which the rain water was collected, were in summer very often empty, as Pouille is one of the hottest regions of Italy, and the Government was compelled to supply drinking water by means of tank ships to towns on the coast, and by tank wagons to the interior. This shortage of the essential element at periods of the year, when disease was more easily disseminated, very often rendered it impossible to successfully combat epidemics, and much suffering was entailed to the inhabitants of the district. All this will in a short time be a thing of the past. Water will now be delivered in ample quantity for domestic purposes and there will also be abundance of water for power and irrigation purposes, which will add to the success of the scheme, for this district is among the most fertile, and its agriculture is one of the sources of wealth of Italy.

The idea of supplying the district with water has existed for centuries, but it has never materialised, on account of the difficulty of obtaining water in sufficient quantity without carrying out enormous work, which could not be done until the progress of engineering had made it possible to construct the extensive borings through the Appennines, in order to reach the sources of supply. The first practical scheme was outlined 45 years ago, in 1868, when a proposition was made to the provincial deputies Council of Bari. For the space of 30 years various surveys were made by the most eminent authorities in Italy, and a preliminary scheme was laid down by the Government in 1899. According to this scheme, the work involved the construction of a main canal from Caposele (420 m. above sea level) to Villa Castelli, over a length of 236.5 km., of which 53.15 km. would have to be tunnelled through the Appennines, 179.2 km. of cuts, and 3.65 km. of syphons. From this main canal 2,500 km. of branch canals and piping would have to be provided, to bring the water to 260 towns in the three provinces of Pouille (Foggia, Bari and Lecce).

Distributed over the whole length are about 150 reservoirs with a total capacity of 286,000 cu. m. and a sufficient number of central power stations, the energy from which was to be used partly for conveying the water to those centres situated at a higher level than the canal, and partly for industrial purposes.

In October, 1902, tenders were invited for the whole enterprise, and in 1905 an Italian company was formed for the purpose of undertaking

THE COLLECTING CANAL IN THE BASIN OF THE SPRINGS, THE DIMENSIONS OF WHICH ARE CALCULATED FOR AN OUTPUT OF SIX CUBIC METRES PER SECOND.

the work and controlling it for 90 years. The two years following the award were devoted by the concessionaries to developing the scheme, and showed the necessity of departing from the original plan, in order to reap some further advantages and overcome more unexpected difficulties. By regular measurements it was ascertained that the mean output of the springs was 5.500 cu. m. per second; this allowing an average supply per inhabitant per diem of 100 litres, and leaving two-thirds of the whole for irrigation and power purposes.

The copious stream of water, necessary for the two million inhabitants, was to be taken from the side of the Appennines, opposite to the one in which the Pouille is situated, in a dis-

A POWER STATION

trict remarkable for the number of water springs and whence another great Italian waterworks, the Serino of Naples, took its supply some 25 years ago. This district, approximately situated in the triangle Avellino-Campagna-Salerno, is characterised by the presence of a group of mountains with numerous plateaus in the form of basins. By reason of their unusual height and the composition of their rocks, which are among the most porous (limestones and dolomites) this group of mountains exercises an important function in the absorption of the water and atmospheric moisture. The conditions under which this water collects are most favourable to its reappearance in the form of springs, the mass of mountain being isolated from the plateau, above which it towers, by a belt of impermeable ground, forming in its interior an immense natural reservoir, from which the water in excess escapes in the form of copious springs at the lower points of the edge of this belt. The area taken in by these porous rocks comprises about 605 sq. km., between Caposele, the right bank of the River Sele, Campagna, Salerno and Avellino; the total volume of water issuing from those springs is never less than 23 cu. m. per second. Of these springs, the most important, from the point of view of their utilisation for the aqueduct, were those emanating from the eastern slope of Mt. Paflagone, which abuts from Mt. Cervialto (1,810 m.) near Caposele. The principal group of the springs issues from a large limestone wall at points having an altitude from 420 to 423 m. above sea level, and describing an arc, the concavity of which faces the east, enclosing the depression where the water collects and whence it is precipitated from a height of 30 m. to form the River Sele.

An accurate geological survey of the local conditions, revealed the existence of a substrata of impermeable clay, lining this depression and naturally protecting the water collected therein against waste due to filtration, so that nothing further was necessary, in order to retain the water and lead

ONE OF THE CANALS IN CUT.

it into the aqueduct, but to close the passage through which it previously escaped. For this purpose a retaining wall extending across this passage was constructed. The wall, which has a thickness of 2 m. and is constructed for half its height of concrete and the upper part of limestones held together with puzzolane, has its foundations in the impermeable strata, the ends of the structure penetrating into the same medium and is almost entirely embedded in the ground. Its top is 2.50 m. below the mean level of the water in the collecting basin.

The water from the rock is collected by twelve canals, each 80 c.m. wide, adjoining the rock at the points where the springs appear more abundantly. These canals have a natural soil bottom and perforated walls formed by concrete bricks of 60 c.m. side, with an opening of 15 c.m. between each; they lead into a collecting canal 55 m. long, with a width increasing from 3 to 5 m., having also a natural soil bottom at a datum maxima of 419 m. over sea level, and with an inclination of 0.5 $^{\circ}/_{\circ\circ}$. The walls of this canal are built of piles, bound together by arches of masonry, the spaces being filled in with the same material as that used for the small canals. The space between the walls of the small canals, the adjacent side of the main one and the rock opposite, as well as the space on the other side of the main canal, in the direction of the retaining wall, until no traces of water appear from the soil, are filled in with a bed of gravel, through which the water, coming from the soil, filters and overflows through the perforated walls into the collecting canals. The bed of gravel is covered by an impermeable strata of concrete 30 cm. thick, rejoining the edges of the collecting canals. The main collecting canal is covered with a reinforced concrete floor, and the small canals with cement slabs. All the collecting zone, from the rock to the retaining wall, is covered with a bed of arable soil 80 cm. deep, protected against percolation of rain water by a perfect system of drainage.

CANAL BRIDGE, SHOWING THE SECTION OF THE AQUEDUCT.

THE COLLECTING CANAL (UNCOVERED), THE SUPPLY CANAL, THE DISCHARGING CHAMBER AND THE PRINCIPAL OPERATING ROOM.

The collecting canal, above described, branches into a supply canal of masonry, 17 m. long and 5 to 4 m. wide, the bottom of which has an inclination equal to that of the collecting canal. When the water in this supply canal reaches a level of 1 m., a volume, exceeding 6 cu. m. per second, can be delivered, which is the maximum quantity available in exceptional years.

At its extremity the floor of the canal is 418.95 m. above sea level, and has a depression 1 m. deep and 6 m. long, terminating two metres before the face over which the water falls : this arrangement is made for the purpose of enabling water to be directed into an auxiliary discharging canal, branching from the main one, which will be described later on. The supply canal leads into a collecting well 7 m. long, 4 m. wide, the bottom of which is 416.50 m. above sea level. The wall opposite the spot where the water arrives, is pierced by two apertures of 1 m. square section, provided with double sluice gates, for the purpose of regulating the inlet of the water to the aqueduct or discharging the entire volume, through a chamber 5 m. long and 3 m. broad, into the ordinary discharging canal.

MARIE CANAL CARRIED OVER VIADUCT

This canal is 74 m. long, has a gradient of 2 % and branches into the old bed of the River Sele.

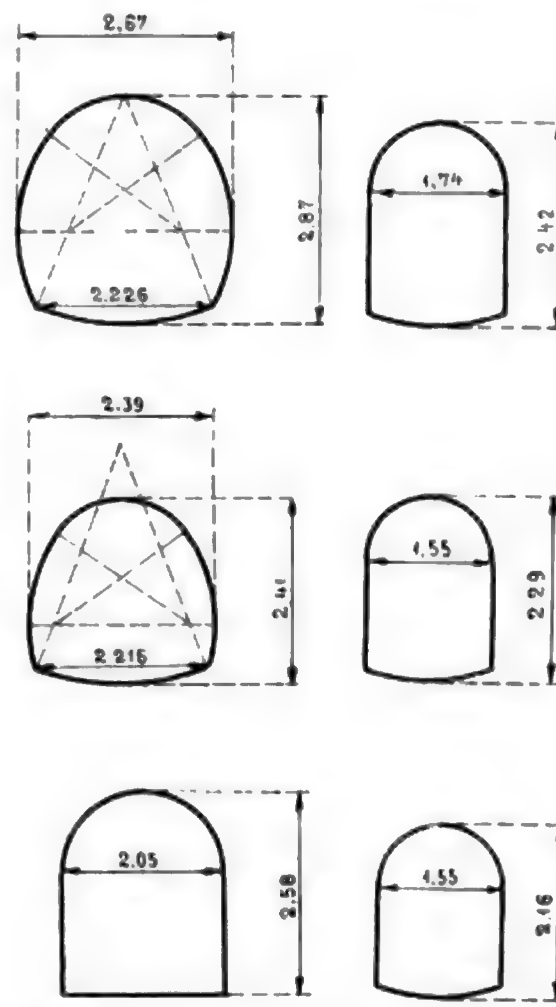
The lower wall of the collecting well contains the weir (418.76 m. above sea level), over which the water falls into a chamber, the edge of which constitutes the starting point of the aqueduct.

The principal operating room (shown in one of the accompanying photographs) (9.30 m. by 5.20 m.) containing the hydrometer and the necessary mechanism for the operating of the sluices is placed above the supply and discharging chambers.

For supplying the town of Caposele, 500 litres per second, if the output of the springs is more than 4 cu. m. and 200 litres, if this output is less, are to be returned to the old bed of the River Sele. This quantity is taken by a canal branching from the collecting canal, in proximity to the south end of the retaining wall. This canal is 1 m. wide and the level of its bottom is 40 cm. lower than the bottom of the collecting canal: it communicates through an opening, regulated by sluicegates, with a basin, ending by a weir over which the water falls back to the old bed of the River Sele in a pipe passing the retaining wall. By regulating the sluice-gate the exact level can be maintained in the basin.

The main canal of the aqueduct, which originates at the above mentioned chamber, runs from Caposele to Fasano. Its length, according to the scheme adopted, is 213.475 km., of which 96.846 km. are tunnelled, 8.509 km. are canal-bridges and 7.390 km. are syphons. Some of the tunnels (the total number of which is 73) are as long as the most famous tunnels through the Alps, viz., the first tunnel through the Appennines (15.268 km.) and the tunnel of Murge (16.021 km.) many others have a greater length than 5 km. Noteworthy is the canal-bridge over the "Vallone di S. Pietro," which is 973 m. long; among the syphons, the most important is that of "Palazzo S. Gervasio," 4341.95 m. long, consisting of two pipes of 1650 mm. diameter.

The main canal is divided into six sections, each dimensioned for an output varying from 5.690 cu. m. to 2 cu. m. per second. The profile of the section is ovoid for the tunnels and cuts in clay ground; rectangular, surrounded by a semi-circle and limited on the bottom by a reversed arch for the cuts in tufaceous rocks and for the canal bridges. Length, output, extreme dimensions of the section and gradient respectively of these parts are as follows:—




SECTIONS OF THE SIX PORTIONS OF THE CANAL.

First section from Caposele to the main branch for the province of Foggia: 55.270 km. 60; 5.690 cu. m.; 2.87 m. by 2.67 m.; 0.25 ‰. Second section, from the Foggia branch to the starting point of the Locone syphon: 29.205 km. 76; 4.670 cu. m.: 2.41 m. by 2.39 m.; 0.40 ‰. Third section, from the starting point of the Locone syphon to the Andria branch 20.955 km. 64; 4.670 cu. m.; 2.58 m. by 2.05 m.; 0.40 ‰. Fourth

ONE OF THE GALLERIES THROUGH THE APPENNINES.

section, from the Andria branch to the Bari one: 40.658 km. 91; 3.100 cu. m.; 2.42 m. by 1.74 m.; 0.28 °/₀₀. Fifth section, from the Bari branch to the Gioia del Colle one: 28.750 km. 72; 2.300 cu. m.; 2.29 m. by 1.55 m.; 0.30 °/₀₀. Sixth section, from the Gioia del Colle branch to Fasano, 38.632 km. 91; 2 cu. m.; 2.16 m. by 1.55 m.; 0.30 °/₀₀.

The first 334 m. of the main canal, extending from Caposele to the Tredogge torrent, are regulated, in order to ascertain the volume of water passing through. The part reserved for this purpose is 107 m. long and has a gradient of 0.25 °/₀₀; its section being rectangular 2.50 m. by 2.60 m., with a cuvette 9 cm. deep. This section is sufficient to allow the passage of 6 cu. m. per second. In the middle there is an enlargement of section, from which starts a chamber 4.5 m. broad and 3 m. long, with two lateral ledges, crossed by a bridge, from which it is possible to measure the volume of water, by means of a Woltmann wheel. This check canal is tunnelled, and access to the operating room is effected through a well 15.80 m. deep and 1.80 m. across.

Along the main canal, there are 25 buildings for the partial or total discharge of the water in natural waterways, so arranged that only the part of the canal comprised between two can be put out of service. For the supervision and conveyance of material there are at present 165 km. of special roads connecting the main canal with the national and provincial roads; to every 6 km. of canal there is a watchman's house.

The supply of water to the 260 towns in the three provinces is assured

through 2,300 km. of canalisation and piping as follows :—

For the province of Foggia, the water is taken by a branch canal extending over 45.963 km. of which 3.428 km. are tunnelled, 13.501 km. 82 are syphons, and 0.469 km. canal-bridges ; this canal is followed by a pressure conduit of 68.116 km. and 207.867 km. canalisation branching from it run to the towns from which 100 km. piping distribute the water to the inhabitants.

There will be 17 reservoirs of a total capacity of 50,900 cu.m. ; nine pumping stations for supplying those centres on a higher level than the canal, and 5 power stations of 1,087 H.P. total output. A most interesting feature is the great syphon of Ofanto, having a length of 5.865 km. ; a normal output of 1,100 litres, and a drop of 29.91 m. (two pipes of 700 mm. dia.).

For the province of Bari, the supply is assured by 860 km. canalisation and piping ; of these 392.300 km. branch directly from the main canal and run to the reservoirs ; 117.700 km. run from the reservoirs to the towns, and 350 km. are piping in the towns themselves. There are 53 reservoirs with a total capacity of 103,000 cu.m. ; 8 pumping stations and 11 power stations with a total output of 3,621 H.P.

Owing to the fact that the whole of the province lies down in the plain, no special structures were there necessary. The supply for the province of Lecce is taken by a branch canal extending over 30.524 km. of which 6 621 km. are tunnelled ; 650 km. canalisation will go from this canal to the towns. There will be 77 reservoirs, with a total capacity of 133,000 cu.m. ; 5 pumping stations and 2 power stations with a total output of 3,987 H.P. A notable piece of work will be the two syphons, one 17.250 km. long and with a drop of 26 m. (Villa Castelli-Oria) ; another one 55 km. long with a drop of 19.28 m. (Oria S. Donato).

With an output of 5,500 cu.m. per second, a supply of 100 litres per inhabitant to a population of 2,000,000 would use only about ⅓ of the total, the rest being available for irrigation and other purposes.

It may be interesting to give some particulars of the power stations which, over the whole length of the aqueduct, utilise the differences in level for the production of energy, a small fraction of which is absorbed by the pump stations, but all the rest is available for external use. The total output (8,685 H.P.) is not a very large one, especially for Italy, which is one of the richest lands in the world in water falls.

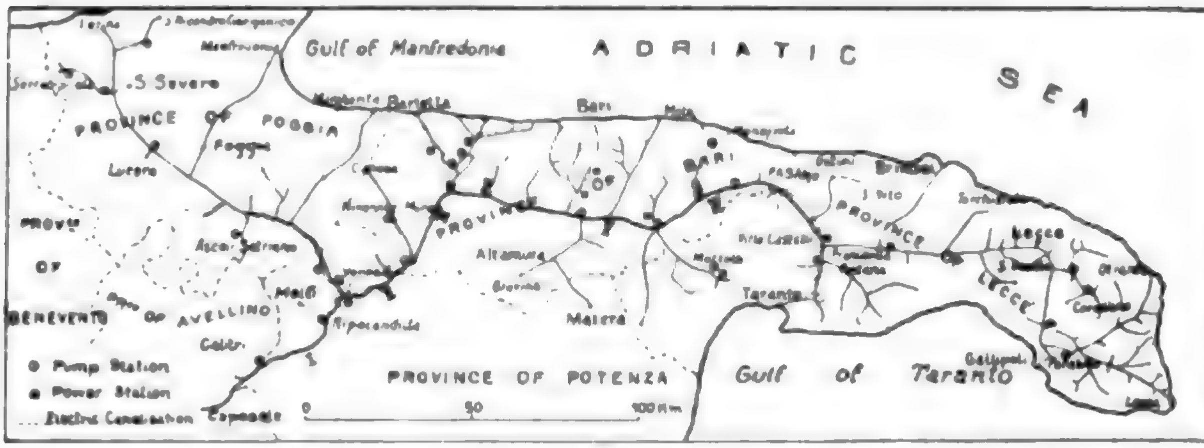
But it is to be noted that in this case, the stations produce energy without any disturbance in the service of the aqueduct, and the water, after having spent its kinetic energy in the turbines, resumes its primary role ; viz., the supply of the surrounding districts ; in consequence no water is wasted for these auxiliary services, which are, therefore, exceptionally cheap. The total number of the power stations is 18. Of these, 13 are of minor importance, their output varying from a minimum of 29 to a maximum of 400 H.P. ; five have an output exceeding 700, and reaching 2,500 H.P. The first power station of this group is on the branch canal for the province of Foggia (Salto del Tuppo) where 1,1000 litres make a drop of 54.20 m., through a pressure conduit of 339 m. length and 1 m. dia., developing 784 H.P.

A second station is situated on a secondary canal, assuring the supply of the towns Andria, Barletta, Corato, Trani, Bisceglie, Molfetta and Giovinazzo, in the province of Bari. In this station 1,120 litres fall 102.45 m. through 2,162 m. pressure conduit of 900 mm. dia., and develop 1,411 H.P.

The third station is on another secondary canal, feeding the town of Bari ; 590 litres fall 106.50 m. through 2313.45 m. conduit of 800 m m. dia. The station gives an output of 799 H.P.

The fourth and most important station is at Villa Castelli, at the end of the branch canal for the province of Lecce. In this station 1627.40 litres have a fall of 118.40 m. ; the pressure conduit has a length of 2008.23 m. and a dia. of 1,300 mm. ; the output of the station is 2,516 H.P.

The fifth station is placed not far from the end of the above mentioned branch canal, at Grottaglie ; 1093.40




MAP OF DISTRICT SERVED BY THE SCHEME, SHOWING POSITION OF CANALS, PUMPING AND POWER HOUSES.

litres there fall 105.80 m. through a pressure conduit of 2,250 m. length and 1 m. dia.; the station develops 1,471 H.P.

The engines to be installed in these stations will be Francis turbines of horizontal type; they will be directly coupled to three-phase alternating current generators of 13,000 volts.

A fraction of the total output of the 18 power stations will be required for the pump stations, numbering 22. Of these stations, five will utilise the energy produced by the falls existing on the spot; of the remaining stations the following are remarkable:—

The station serving the towns of Altamura and Gravina, where 55 litres have to be raised 158.91 m. through 7,040 m. of piping having a diam. of 400 mm.; the power required for this station will be 200 H.P. The station of Galatone, where 106.4 litres have to be pumped 40.50 m. through 2795.80 m. piping of 600 mm. dia.; the power absorbed will be 124 H.P.

The station of Parabita, the most important one; 79.7 litres to be raised 99.50 m. through 2,340 m. piping of 500 mm. dia. with an expenditure of 224 H.P.

There are many other stations raising only small quantities, to heights not exceeding 200 m. The pumps installed in these stations will be of the centrifugal type; single, for the stations of minor importance; multiplex, high pressure, for the others; total energy required by the 22 stations will be 1,267 B.H.P.

The work is so far on the way to completion that the first 65 towns in the three provinces will be supplied with water long before the stipulated date. Lecce, and the centres of its provinces, which are at the greatest distance from the end of the main canal, will be supplied with water in 1915. The whole aqueduct is to be opened in the month of August, 1916.

A few more months, and the "siticulosae Apuliae" of Horace will be but a dead recollection. After centuries of torments of thirst, which there seemed to be no means of mitigating, a copious stream of water will, at length, bring to the inhabitants of Pouille life and prosperity. This is a work of which modern Italy can be proud, as an engineering feat which will remain long without rival.

# A NEW METHOD OF COOLING GAS-ENGINES*

By Professor Bertram Hopkinson, F.R.S.

THE most important peculiarity of the gas-engine, that which determines the characteristic features of its design and operation, is the heat-flow from the hot gases into the cylinder walls. About 30 per cent. of the heating value of the fuel passes into the metal of the engine in this way, and it is necessary to provide means for its removal as fast as it goes in. In all engines hitherto made (except the small air-cooled engines) the removal of the heat has been affected by the circulation of water round the cylinder, and (in large engines) in the substance of the piston and exhaust-valve. External water-cooling is the ultimate cause of most of the disadvantages under which the gas-engine has hitherto laboured and which have retarded its development in large sizes. It is obvious that the provision of a jacket, and of the elaborate appliances necessary for the circulation of water in the moving piston and exhaust-valve, must be largely responsible for the great weight and cost of large engines of this type.

For many purposes these disadvantages might not in themselves be serious, having regard to the superior economy, were it not that there are secondary effects of this method of cooling which tend to make a large engine unreliable in working. In order that the heat may be caused to flow from the inner surface of the metal where it enters to the outer surface where it is removed, there must be a difference of temperature between these surfaces proportionate to the thickness. The necessary difference is of the order of 50° C. per inch, and while not of much moment in small engines, it may become serious in large sizes where the cylinder-walls are in places 3 inches thick or more. Furthermore, it is difficult in large engines to secure an adequate circulation about all parts of the cylinder-walls and piston, and some parts may become much hotter than others. The inequalities of temperature so set up in the metal are detrimental in two ways. In the first place they cause stresses, which are very liable to crack a casting already (by reason of the double wall required to form the jacket) difficult enough to design and manufacture. Secondly, the overheating of certain parts of the inner surface, whose temperature as pointed out is much above that of the water, is apt to cause pre-ignition of the charge, especially if deposits of carbon or tar are formed. Such deposits on a surface already overheated may, owing to their poor conducting power, easily reach a temperature sufficient to fire the charge before the proper time. Pre-ignitions so caused, apart from their effect in reducing the efficiency and power of the engine, are a source of danger because they cause an excessive development of heat especially in the neighbourhood of the pre-igniting point, and also result in higher maximum pressures. In consequence of the dangers of overheating, it has been found impossible to work gas-engines, especially of large size, continuously at the maximum power which they can develop. In order to obtain at all satisfactory results, it is necessary to use weak mixtures and even so trouble is apt to arise for the reasons stated. If it were possible to allow large gas-engines to work continuously at the maximum power which they are capable of developing for short periods, the cost per horse-power would be reduced from 20 to 40 per cent.

COOLING BY INTERNAL INJECTION.—When once these difficulties, and their

*Read at the Cambridge meeting of the Institution of Mechanical Engineers.

cause, have been clearly stated, it seems fairly obvious that they can be overcome by applying the cooling medium on the inside of the cylinder instead of to the outer surface. If water can be injected internally against the surfaces to be cooled, the heat is removed on that side of the metal on which it is generated, and there is no heat-flow through the metal and no difference of temperature between the inner and outer surfaces. The water may be distributed by means of jets so that each part receives it in proportion to the rate at which it receives heat from the hot gases. Thus the engine can be maintained at substantially the same temperature all over and the stresses due to unequal heating may be eliminated. A simple single-walled casting can be used for the cylinder, resulting in a great saving in weight and cost and in improved reliability on account of the elimination of casting stresses. The arrangements for cooling the piston, which are necessary in large engines, can be dispensed with—a point of great importance, because these arrangements, besides being costly, frequently give trouble, and their failure may easily result in wrecking the engine. Finally, pre-ignitions are entirely prevented, for even a thick deposit of carbon, being cooled by the projection of water against the surface into which the heat flows, is kept at a temperature much below that full red heat which is necessary to fire the charge.

The idea of introducing water into an internal-combustion engine is not new. It is a common practice in oil-engines to introduce water along with the oil in order to enable the compression to be raised, and water has been sprayed into gas-engines for the purpose of preventing pre-ignition. Proposals have also been made to introduce water for the purpose of cooling parts of the metal. None of the latter, however, has been a practical success, if indeed they have ever been more than suggestions on paper, apparently because their originators did not appreciate the conditions which must be satisfied if the injected water is to act as an effective cooling agent. Of these the most important is that the water must be projected in comparatively coarse drops or jets directly against the surfaces to be cooled, so that it reaches these surfaces in the liquid form without much loss by evaporation on the way. Further, it must be distributed properly, so that each portion of the metal receives water in the proportion in which it receives heat. If the water be turned into steam before reaching the metal, it will not exert any cooling effect except indirectly by lowering the temperature of the flame, and such lowered temperature is accompanied by a considerable loss of efficiency.* If the water is not

* As there exists, even now, some misapprehensions about this point it may be well to explain it rather more fully. Suppose that water to such an amount that its evaporation would absorb, say, one-tenth of the heat of combustion is injected into the cylinder at the moment of explosion, and that the whole of this water is evaporated in the flame and before it reaches the walls. The effect on the flame temperature will be substantially the same as though the supply of the combustible gas had been diminished by the amount required to evaporate the water, that is, in the ratio of 10 to 9, and there will be a corresponding reduction both in the flame temperature and in the flow of heat from the hot gases to the walls. Thus the heat which must be removed by the jacket-water or by evaporation of liquid on the walls will be reduced by roughly one-tenth of itself or, say, from 30 per cent. of the heat of combustion to 27 per cent. The absolute reduction in heat-flow is only of the order of one-third of the heat of evaporation of the water, and it is obviously impossible by this means to reduce the heat-flow to such a point that an external water-jacket can be dispensed with. Moreover, evaporation of water in the flame is accompanied by a considerable reduction in thermodynamic efficiency, because the suppression of the heat required for the evaporation of the water is only very partially counteracted by the added pressure due to the formation of the steam. Roughly speaking, any reduction in heat-flow due to evaporation of water in the flame must be accompanied by a reduction of the same order of magnitude in the work done.

On the other hand, water which reaches the walls in the liquid form and is there evaporated absorbs out of the heat given to the walls by the gas the *whole* of its own heat of evaporation, and there is no loss of thermodynamic efficiency because the heat used is waste heat which in a jacketed engine would go to warm the cooling water. Any steam formed in this way is pure gain; and, if anything, there is an increase in the work done

properly distributed, those portions of the cylinder-walls and piston which do not receive an adequate supply must lose by conduction to the properly cooled portions the heat which they receive and, in consequence of the inequalities of temperature so set up, an important advantage of this method of cooling (substantially uniform temperature) is lost. It is of no use to inject the water in a fine spray produced by an atomiser, or to introduce it into the gas or air-pipe, so that it is carried in suspended in the incoming charge or (as is often done in oil-engines) to spray it in along with the oil. Though some of these devices have proved useful for the prevention of pre-ignition and for the softening of the explosion, none of them is effective for the purpose of cooling. For that purpose it is necessary to project the water positively and directly against the metal surfaces, by means of properly arranged nozzles in a rose, or its equivalent, projecting into the combustion-chamber.

The method of internal injection described in this paper embodies this principle. Cold water is injected through a hollow casting projecting into the combustion-chamber and provided with a number of holes or small nozzles about 1-32 in. in diameter. The jets so formed are comparatively coarse, so that even when projected into the flame the water reaches the part of the wall against which it is directed with but little evaporation on the way. The jets are directed to all parts of the surface of the combustion-chamber and against the face of the piston.

The projection of liquid water against the walls and the proper distribution of that water are the first essentials of effective cooling by water-injection; but there are other conditions which must be satisfied in order that the system may be a practical success. It is the experience of all who have had much to do with gas-engines, that whenever liquid water has by accident or design been allowed to accumulate on the inner surface of the cylinder, it has been found to have very deleterious effects. Most producer gas contains a certain proportion of sulphur dioxide. This dissolves very readily in cold water forming sulphurous acid which rapidly corrodes any metal surface with which it may be in contact. Thus, if the cylinder-walls are allowed to become and remain wet, they are rapidly destroyed by corrosion. Even when the gas does not contain sulphur dioxide, liquid water spoils the working of the engine by washing away the lubricant.

When the author first began to consider the use of internal injection as a means of cooling, these difficulties of corrosion and lubrication seemed to be an insuperable bar, until it occurred to him that they could probably be overcome by the simple device of regulating the amount of water injected in such a way that the temperature of the whole of the engine is kept well above 100° C. Under such conditions (which, of course, are only rendered possible by the absence of all external water-cooling) every drop of injected water is boiled when it reaches the walls, and no liquid can accumulate. The large drops of water projected from the nozzles can dissolve but little gas on their way to the walls, for their surface is relatively small and they are only in contact with the gas for a fraction of a second. What little they do absorb is at once driven off when they strike the hot metal, because the water is almost instantly converted into steam. That corrosion may be completely prevented in this way has been proved by actual trials, of which further particulars are given later.

The practical application of this system of cooling has been much facilitated by a discovery made by the author soon after he began experimenting with it. It was well known from the experiments of Dr. Dugald Clerk, the author, and others, that the rate of heat-flow from the gas into the metal is far more rapid at, and soon after, the moment of ignition than at any other time. It seemed likely from these experiments that for practical purposes the heat-flow into the barrel of the cylinder during the last three-fourths of the expansion stroke might be so small compared with that in the first period that direct cooling of this portion of the cylinder could

be dispensed with altogether. This anticipation has been found to be correct. It is sufficient to inject water on to the surface of the combustion chamber and the head of the piston only, the whole of the cooling of the barrel being effected by conduction into the piston which is itself kept cool by the projection of water on to the head when it is near the in-centre. This, of course, is the opposite of what occurs in a jacketed engine, in which the heat flows from the piston into the jacketed barrel. By taking advantage of this fact, the application of water is confined to places where it can do no harm, none falling on the sliding surfaces. This is a point of some importance if the water contains much dissolved matter. The experimental engine described below has been worked for some thousands of hours and is now working with a very hard water containing about 0.35 gramme of salts to the litre (25½ grains to the gallon), so that the surface of the combustion-chamber and the ace of the piston have become thickly encrusted with salts. Yet no trouble whatever has arisen, because no water has been allowed to fall on the sliding surfaces. The absence of pre-ignition under such conditions is also noteworthy and shows the efficiency of this method of cooling.

### Trials of 50-B.H.P. Engine.

*Description of Engine and Injection, Apparatus.* In order to put these ideas to a practical test, a Crossley engine, 11½ inches diameter by 21 inches stroke rated at 40 B.H.P. (with coal gas) at 180 revolutions per minute, was fitted with a new cylinder consisting of a plain barrel without any water-jacket. The valve motions were retained, and the valves and the shape of the combustion-chamber were the same, the only change being the removal of all external water-cooling. It was therefore possible to make an accurate comparison between the performance of the engine with the new system of cooling, and the results of the measurements of fuel economy and the temperatures of the piston and other parts of the engine which had been made by the author on the same engine when jacketed. The compression ratio in the engine is 6.37, giving a compression pressure of about 175 lb. per square inch abs. This is higher than is usual, and proved, when the engine was jacketed, to be too high for ordinary practical working. The successful working of the new cylinder, therefore, constitutes a satisfactory proof of the freedom from pre-ignition which is characteristic of cooling by water injection.

A section of the new cylinder with water-injection rose is shown in Fig. 1. The injection-rose is a hollow casting, projecting into the combustion-chamber. There are about twenty-five holes in the rose, each $\frac{1}{16}$ inch in diameter, and the jets proceeding from these are directed as shown against all parts of the combustion-chamber and piston-head. There is no jet on to the exhaust-valve, as it has been found that the drip from the rose is sufficient to keep this cool. The water is injected by a simple plunger pump of the same kind as that used for the injection of fuel in Messrs. Hornsby's oil-engines. It is driven by a cam on the valve-shaft, whereby a charge of water is injected once in a cycle. The pump-stroke commences about 30° before and finishes about 30° after the point of ignition, so that water only goes in at a time when practically the whole of the sliding surface of the barrel is covered by the piston.

*Fuel Economy and Consumption of Water.*—Immediately after erection with the new cylinder, the engine was run continuously for 120 hours on an electrical load with coal-gas. Continuous observation was kept of the gas consumption and of the load. The engine developed during this period 43 B.H.P. on the average, and ran very smoothly and steadily. The average mean effective pressure was 101 lb. per square inch. When jacketed, the engine would not develop more than 40 B.H.P. continuously without overheating, and mixtures giving a mean pressure of more than 100 lb. per square inch produced excessive maximum pressures (over 500 lb.) with violent thumping explosions. The reduction in maximum pressure, under these circumstances, by water injection is over 100 lb. per square inch, and the effect is very marked, the explosion

becoming almost inaudible. This effect of the presence of steam in the explosive charge is, of course, well known, but the quantity of steam formed in an engine cooled in this manner is so large that it constitutes a substantial advantage of the method. It will be noticed that the formation of the steam does not involve any thermodynamic loss, such as occurs when water is sprayed into the cylinder in an atomised condition and evaporated before reaching the walls, since the heat used is that which would otherwise be wasted in the jacket-water.

The quantity of water used on this trial was on the average 102 lb. per hour, equivalent to 2.4 lb. per B.H.P. hour. The temperature of the engine varied from 150° to 180° C. No water was visible on the piston or the spindles of the valves, and when the engine was stopped at the end of the trial the inside of the combustion-chamber was found to be perfectly dry. When the engine was jacketed and giving the same power for short periods the jacket water removed about 67,000 B.Th.U. per hour, which would be sufficient to evaporate 108 lb. of water at a temperature of 20° C. under atmospheric pressures. The agreement between the available heat and the amount of water evaporated is satisfactory, such difference as there is being accounted for partly by greater radiation loss consequent on the higher temperature of the engine, and partly by the reduction in flame temperature produced by the steam, which somewhat reduces the total amount of heat passing into the walls.

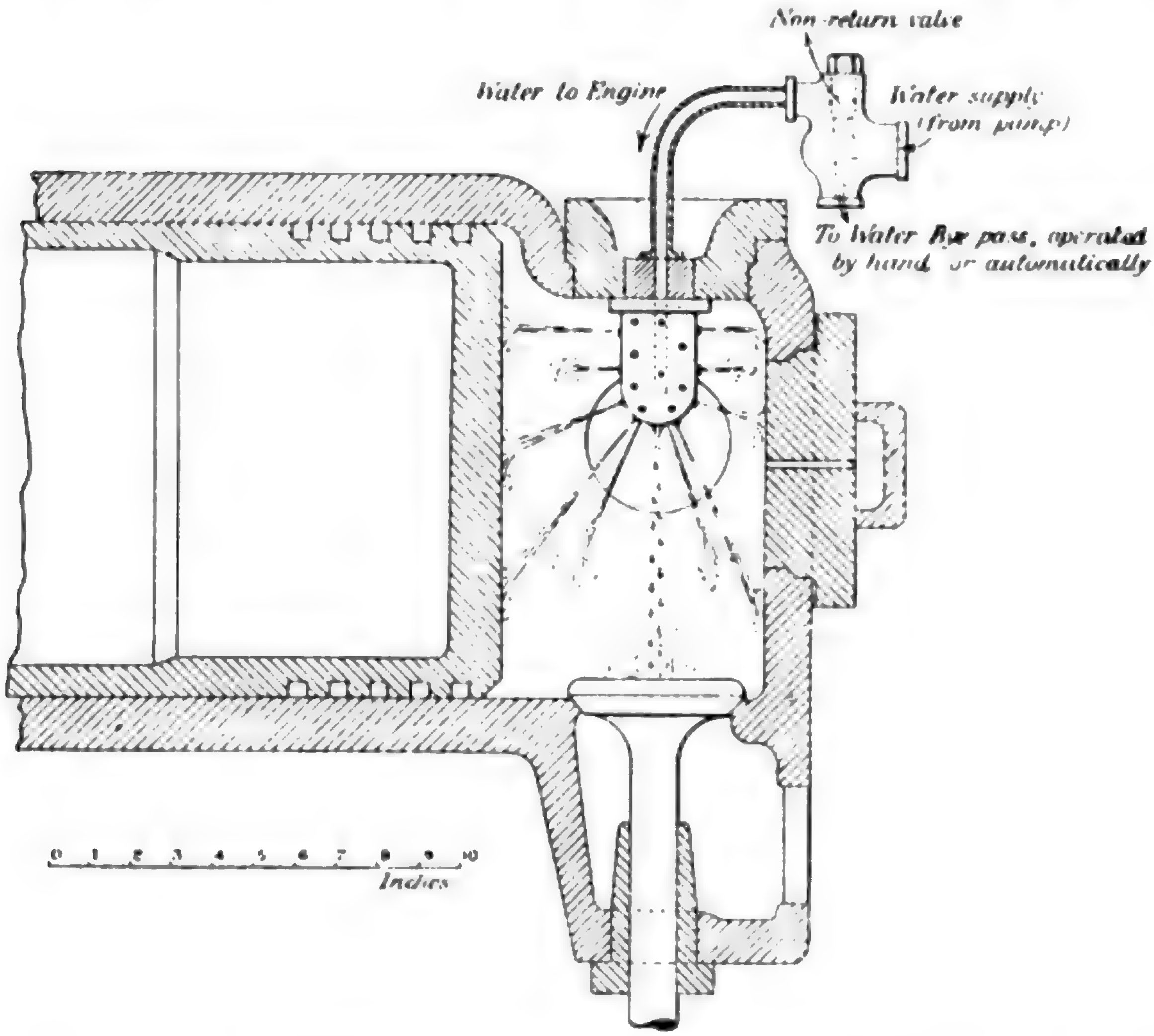



FIG. 1.—SECTION OF CYLINDER WITH WATER-INJECTION ROSE.

The engine consumed in this trial 15 cubic feet of Cambridge coal-gas per B.H.P. hour reckoned at atmos-

pheric temperature and pressure. This is approximately the same as it burnt when developing the same power for short periods when jacketed. Tests at other loads have shown that with a weak mixture the gas consumption is slightly increased by the water-injection, but with very strong mixtures it is a trifle less. The difference, however, does not exceed five per cent. either way, and on the average it may be said that the economy is unaffected by the use of this method of cooling. Indicator diagrams taken in this long trial are shown in Fig. 2, and a comparison of these with similar diagrams taken from the jacketed engine shows that the reduction in maximum pressure is counterbalanced by a slightly raised expansion line. The pressure is better sustained, partly by the formation of the steam and partly by the reduced loss of heat, with the result that the diagram is "fatter" and less "peaky."

*Reliability and Wear under ordinary Working Conditions.*—After the trial just described, the engine was put to drive a dynamo in a factory engine-room. Its speed was increased from 180 to 195 revolutions per minute. It was left in the hands of the ordinary engine-room staff for several weeks; and was worked continuously for long periods of time at excessive loads. During this time it developed at times 50 B.H.P. with coal-gas for several hours together—an increase of 25 per cent. on the maximum continuous load which it could safely carry when jacketed. Since then the engine has been brought to Cambridge, and is now engaged in regular service with a suction-producer driving the workshops and producing electric current for the engineering laboratory. It is left to itself like an ordinary gas-engine, giving no trouble at all, and has now been in regular work for two years, the total time of running being 5,000 hours.

Anthracite coal is used in the producer, and this coal contains a considerable proportion of sulphur. Yet there has been no trace of corrosion in the engine. That the corrosion would be rapid if liquid water were allowed to accumulate is shown by the experience with the nozzles in the injection-rose. These nozzles are, of course, continually in contact with water, and were at first found to corrode away rapidly. After many trials a suitable material has been found which lasts very well. Some corrosion has been observed at the bends of the exhaust-pipe where the gases impinge on the metal, and corrosion in the exhaust-pipe is also liable to occur at any place where water can accumulate. This, however, is not serious or rapid, and such as it can easily be avoided by suitably arranging the pipe. Except at these points, no corrosion has been observed anywhere, and the experience of this engine has completely proved that the necessary and sufficient condition for the prevention of corrosion is that the engine should be kept so hot that all the water is boiled.

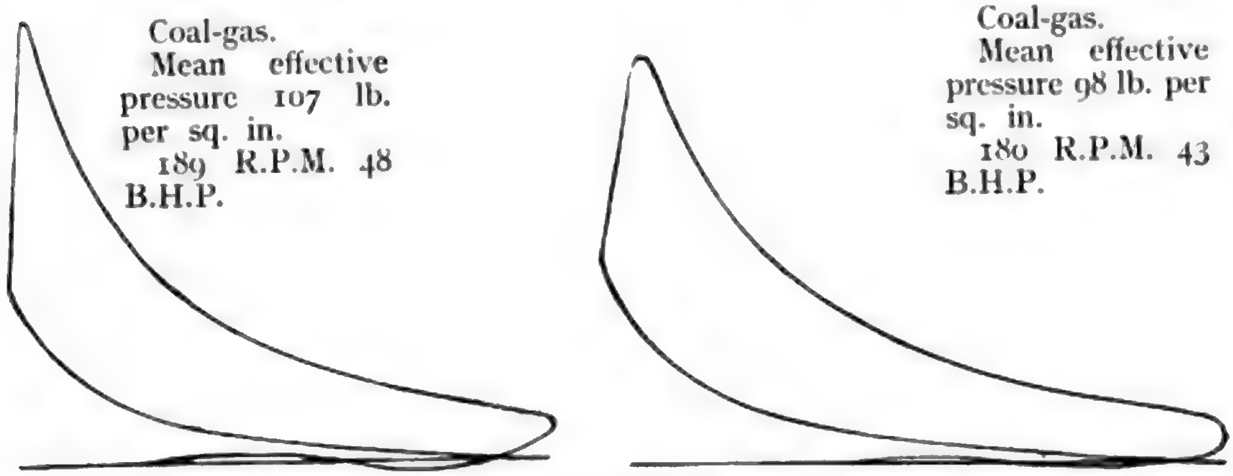



FIG. 2.—INDICATOR DIAGRAMS FROM JACKETLESS ENGINE FITTED WITH WATER-INJECTION.

The cylinder was at first lubricated with a thick oil, such as is used with superheated steam in steam-engines. A gallon of this oil, costing 3s. 3d., lasts for 160 hours, equivalent to about one farthing per hour, or, say, 0.006d. per B.H.P. hour. The lubrication was entirely satisfactory. During the past year "Super Mazoot" oil supplied by the Henry Wells Oil Company has been used. This oil is much cheaper, but it is not quite so clean. The balance of advantage remains with it, however, and its use is being continued. Accurate measurements of the cylinder and piston have been made, with the following results:—

| — | As delivered from makers. | After 200 hours' running. | After 1,000 hours' running. | After 4,000 hours' running. |
|---|---|---|---|---|
| | inches | inches | inches. | inches. |
| Piston, breach end | 11·475 | 11·474 | 11·4735 | 11·472 |
| „ crank end | 11·490 | 11·489 | 11·489 | 11·489 |
| Cylinder, breach end | 11·50 | 11·50 | 11·50 | 11·505 |
| „ crank end | 11·502 | 11·502 | 11·502 | 11·502 |

It is quite certain that the combined wear (on cylinder and piston together) in the course of 4,000 hours has nowhere exceeded one hundredth of an inch. Over the greater part of the surfaces it is much less, and in many places the tool-marks are still visible.

*Regulation of Water-Supply.*—The ordinary working temperature of the cylinder is about 160°C., but the engine will run satisfactorily at any temperature between 120° C. and 200° C. In order to keep the temperature between these limits, some regulation of the water-supply in accordance with the load is necessary. In the engine under consideration, which governs by hit and miss, this regulation is effected by coupling the pump to the governor so that the pump only takes a stroke when the engine takes gas. This method of regulation gives rather too much water at very low loads, but is satisfactory between the limits one-third and full load. With a throttle governor it is easy to connect the gas-supply and the water-supply in such a way that the correct amount of water is delivered at all loads.

When starting the engine cold, the adjustment just described gives too much water, and some of the water must be by-passed until the engine is warmed up. This may be done by hand, for which purpose a small screw-down by-pass valve, admitting of fine adjustment, is provided. In large engines there is no reason why hand adjustment should not be used during warming up, since there must be some one attending to the engine during this period. In smaller engines, however, it is important to make the whole thing automatic. For this purpose a simple form of thermostat has been designed, which opens the by-pass valve if the temperature falls too low. The design of a thermostat which could be relied upon proved to be difficult, but the difficulties have now been overcome, and a very simple and cheap form has been devised. It has been in use for some months, and is quite satisfactory. Once adjusted, it need never be touched and the engine can be started up in the morning day after day, and left to itself, no attention whatever being paid to the water-supply. This thermostat, though especially valuable for small engines when it is desired to reduce the attendance to a minimum, will be of use also for larger sizes, since it deals automatically with changes in the quality of the gas.

*Safety Plug.*—It is one of the advantages of this method of cooling that failure of the water-supply—such as may occasionally occur owing to the pump-valve sticking—entails nothing worse than a temporary shut-down. If the water-cooling of the piston in a large gas-engine is stopped for a few minutes the engine is very likely to be wrecked by the seizing of the expanding piston in the cold cylinder. But if the engine is cooled by injection, nothing of the kind can occur because the various parts of the engine all heat up together. If the water-supply be shut off, the engine heats up quite slowly, and if unattended it stops by the occurrence of pre-ignitions arising usually from the injection-rose. Even in a 36-inch cylinder it has been found that no serious harm is done by such an event.

In order to minimise the inconvenience, and to guard against any danger, arising from failure of the water-supply, however, the engine is provided with a fusible plug, screwed into the wall of the combustion-chamber. Should the temperature rise above about 200° C.—quite a safe working temperature—the plug melts and the noise of the escaping gases warns the attendant. This simple device has been thoroughly tested and has been found absolutely reliable. If, with the engine running at full load, the water be shut off completely, the engine heats up quite slowly, taking perhaps ten minutes or a quarter of an hour to reach the point at which the plug goes. There is thus ample time, before the engine becomes dangerously overheated, to reduce the load (if necessary) and to attend to any small defect such as a stuck valve or blocked pipe. A screw-down valve is provided for closing the hole made by the fusion of the plug, so that it is not necessary to stop the engine for its replacement until a convenient time.

*Trials of Large Engines.*—From the nature of this method of cooling it seemed almost certain that its effectiveness would be independent of the size of the engine. Each square foot of metal receives a certain amount of heat from the gas, and it is only necessary to deliver to that square foot as much water as will be evaporated by the heat which it receives. The heat received per unit area is greater in a large engine than in a small one, but it did not seem probable that this would materially affect the matter. The truth of this anticipation has been proved by applying the method to the cooling of larger engines—one an engine of 18½ inches bore giving 105 b.h.p., the other a 1,000 h.p. Oechelhauser engine of 36 inches bore. To the makers and owners of these engines—the National Gas-Engine Co. and Messrs. W. Beardmore and Co.—the author is much indebted for the facilities given. In each case the water was simply run out of the jackets, the injection-rose fitted, and the engine put again to its ordinary work, which was that of supplying electric power to the factory. The trial of the large Oechelhauser engine is perhaps the more interesting. Three injection-roses were at first used, spaced equally round the combustion-chamber and mid-way between the pistons. There were forty-five jets, each 1-16th inch diameter, arranged to deliver water all over the piston-heads and the surface of the combustion-chamber. The pump was driven by an eccentric on the side-shaft and was fitted with a valve which confined the delivery of water to the period 45° before and 45° after the in-centre, the rest of the pump stroke being by-passed. There were two thermo-couples in each piston-head and a number of thermometers in different parts of the barrel; and the temperatures were controlled by adjusting, by means of throttle-valves, the flow of water to the different roses. With no water in the jackets or pistons, the temperature of every part of the engine when on full load could be kept between 100° and 200° C. The engine was taking full load within a few hours of fitting the apparatus, and ran for 30 hours without a stop. After stopping for a short time for adjustments it ran continuously for 70 hours under the same conditions, taking the ordinary factory working-load, which would fluctuate about an average of 800 b.h.p. Failure of the water-supply, which occurred once or twice in consequence of the temporary nature of the pump gear, did no harm beyond causing some pre-ignitions from the roses and necessitating a reduction of load for a short time. In fact, the engine heats up so slowly and uniformly that there is ample time to deal with such a failure before anything serious happens. The quantity of water used was about 2.4 lb. per b.h.p.-hour, and it is interesting to note that this quantity seems almost independent of the size of the engine. This is in accordance with the recent developments of gas-engine theory, according to which the heat loss from flame, being largely due to radiation, increases greatly with the depth of the flame, so that the heat-flow per square foot into the metal of a large

engine is bigger than in a small engine, though the flame temperature may be the same.

The trials of this large engine, which continued for a considerable time, proved beyond any question that the largest cylinders now built can be cooled entirely by water-injection, if applied in accordance with the principles here enunciated. They also showed, however, as might be expected, that for ordinary commercial use the cylinder must be properly designed with a view to the employment of this method of cooling. The most obvious point is that the cylinder must be a plain barrel without any jacket. In the Oechelhauser engine the jacket could only be removed, and the liner exposed, just round the combustion space. The rest of the barrel was surrounded by the jacket which not only made access difficult for the measurement of temperature, etc., but also (the water space being, of course, filled with air) formed a most efficient heat insulator, thus greatly complicating the problem of cooling. Some trouble was experienced because of this, in controlling properly the temperature of the exhaust ports and of the cylinder near them. Further, a good deal of hand regulation of the water was required, as the means of automatic regulation which have since been perfected were not available at that time. In fact, the experiment of running a 1,000 h.p. jacketed cylinder without any water in the jackets was rather in the nature of a *tour de force*, and did not prove to be the best way of developing the idea commercially and in detail. It was, however, an interesting and striking experiment, which showed in a most convincing way the great capacity of the method of internal injection. The whole injection apparatus was made and put together in Cambridge; it cost about £20, and within a few hours of fitting it on the engine it was doing all the work of the complicated and costly plant—cooling tower, centrifugal pumps, 8-inch water mains, and the like—which is necessary for the cooling service of an engine of this size when jacketed. The author takes this opportunity of expressing his thanks to the engineers of Messrs. Beardmore and Co., and particularly to Mr. Stokes, the head of their gas-engine department, for their unfailing courtesy and kindness to him during these trials, which occurred at a time of great pressure of work in the factory, and must have added materially to the burdens of the power-station staff.

The difficulties incident to carrying out experiments on an engine which is in regular use for power supply and cannot be shut down when required for adjustment and alteration, determined the author, with Messrs. Beardmore's consent, to abandon for the time the experiments in Glasgow, and to build an entirely new engine designed *ab initio* with a view to the use of water-injection; and such as might, with but small modification, be put on the market. Arrangements with this object were made with Messrs. Davey, Paxman and Co. The new engine, which is completed and is now undergoing trials, embodies all the experience gained in the experiments which have been described. It is a 2-cycle, single-acting engine, 18 inches diameter by 24 inches stroke, with separate gas- and air-pumps, and is cooled entirely by water-injection.

The author wishes to acknowledge the valuable services of his assistant, Mr. A. L. Bird, in connection with the experiments referred to in this paper. In addition to supervising the trials of engines, Mr. Bird has done most of the work of detailed design, and several novel features in the new engine are largely due to him.

# SOME INDUSTRIAL USES OF TOWN'S GAS

## A REVIEW OF GAS FURNACE WORK AND PRACTICE IN THE STEEL INDUSTRIES OF SHEFFIELD

By Arthur Mead

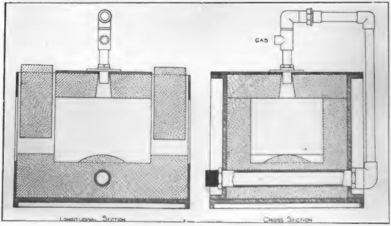
THE employment of town's gas for industrial heating is becoming increasingly more emphasised, and where this is supplied at the price which prevails in Sheffield in which city the minimum charge is 10d., and the maximum 1s. 3d. per 1,000 cubic ft. (a consumer of 10 million cubic ft. per annum, which is not uncommon in Sheffield, pays an average price of 11.37d. per 1,000 cubic ft.) it will be realised that the day is not far distant when this method of heat production will outrival all others, for it is undisputed that cleanliness, absence of smoke and dirt, rapidity and even heating as well as nicety of heat regulation are all factors which recommend the use of gas furnaces in preference to those heated by solid fuel. When therefore the price of gas is such that it can compete in actual fuel costs with solid fuel, the only obstacles in the way of advancement are prejudice and ignorance of the advantages to be obtained, and in Sheffield an effort has been made to overcome such prejudice by educating consumers in the use of gas for the various heating processes to which steel and steel goods are subjected.

The Sheffield United Gas Light Company have for many years recognised the importance of developing the industrial uses of gas and they have been accustomed to advise consumers as to the construction of furnaces and burners. It was felt, however, that something more than this was required and, as an outcome, a small furnace experimental workshop was fitted up in 1909 when manufacturers in the town were invited by circulars and personal visits to inspect the furnaces and to bring their practical men, along with their materials, to make actual trials in properly constructed apparatus. These efforts met with so favourable a reception that it was soon found necessary to remove into much larger quarters and two years ago a workshop was equipped with 20 furnaces upon a practical scale. In addition, a power hammer for forging purposes was put down, sperm oil, brine and water tanks for quenching when hardening were supplied, as well as lifting and carrying tackle for heavy goods, and a gas compressor. The gas supply is obtained from a driving main at about 10 ins. pressure, and this is governed down at the inlet of the meter to any desired pressure, usually 2 ins. for ordinary low pressure work. The meter is constructed to pass 3,000 cubic ft. of gas per hour, and the furnaces are all connected up so that the gas consumption of each can be accurately measured. Air blast pipes with the pressure under control and adjustment up to 2½ lbs. are also fitted capable of delivering 50,000 cubic ft. per hour. The high pressure gas supply from the compressor is also capable of adjustment of pressure up to about 5 lbs., and is registered by the meter as low pressure gas, compression being effected after registration. Pressure gauges, pyrometers and thermometers complete the equipment, which is sufficient to obtain and observe any desired conditions. The furnaces fitted have been made expressly for use in the Sheffield trades and are the outcome of a careful study of the particular needs of the manufacturers, it being found at an early stage of developments, that there were very few stock patterns which exactly met requirements. A view of the workshop is shown in Fig. 1.

In addition to experimental plant for

FIG. 1.—SHEFFIELD UNITED GAS LIGHT COMPANY'S EXPERIMENTAL WORKSHOP.

use in other trades in the town, the following apparati have been installed for dealing with the heat treatments of steel. Four forging furnaces of graded sizes; three annealing furnaces, two of which can attain the temperature necessary to carry out the hardening of high speed steel and the other, that for carbon steel for which process they are frequently used; lead and salt baths




FIGS. 2 & 3.—FORGING FURNACE BY THE RICHMONDS GAS STOVE & METER CO., LTD., OF WARRINGTON AND LONDON.

giving temperatures up to 850°C. used for hardening files, joiners' tools, etc.; oil bath for tempering; two tempering plates; low temperature (350°-400°C). lead bath softening furnaces and four crucible furnaces for melting small charges of metal or alloys and for use in hardening high speed twist drills and cutters; also a high temperature oven furnace, giving a maximum of 1,500°C. which is employed for hardening high speed steel as well as for certain classes of forging and drop forging. A description of the above mentioned furnaces, the methods of working them and their uses will give an insight into the adaptability of gas as a fuel.

interior dimensions 4½ ins. back to front by 9 ins. wide by 4½ ins. high, fitted with one ¾ in. burner in the top. This is largely employed for the forging of standard sizes of files (say 10 ins. to 14 ins.) The working consumption of gas for this purpose averages somewhat under 75 cubic ft. per hour which at the Sheffield price of gas costs approximately one penny. As over one file per minute can be forged in this way the fuel cost per dozen is seen to be extremely small. An additional advantage is that the proportion of "wasters" is considerably diminished if not entirely eliminated. The service of a furnace boy can also be dispensed with.

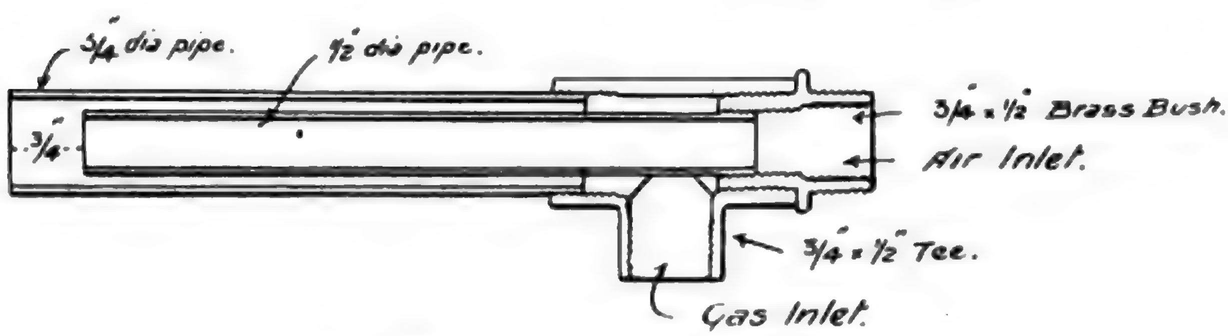



FIG. 4.—GAS AND AIR BLAST FURNACE BURNER.

The forging furnaces (Figs. 2 and 3) are single chambers of cast iron and mild steel plates lined with good quality firebricks in the sides and bottoms, a tiled top in the smaller sizes and arched bricks in the larger. Front and back are so constructed that the tiles can be adjusted to make any required size of opening. Gas is supplied at ordinary pressure, and air blast at about 1 lb. pressure. These are admitted usually through the top of the furnace by one or more burners of sizes varying from ½ in. iron pipe upwards. These burners are of simple design and can be made up by any gas fitter, all that is required being two short lengths of ordinary gas piping, one iron tee piece, equal through with reduced centre and a brass male and female threaded bush to take the inner pipe. Fig. 4 shows a ¾ in. burner in section. This burner has been found by the writer to give as good an efficiency as any of the more complicated and expensive burners upon the market. A popular size of furnace is one having

Amongst the many other uses for which these furnaces are employed may be mentioned, the forging of chisels, plane irons and other joiners' tools, forks, shovels, and numerous agricultural implements, table blades and various descriptions of knives and cutlery also for heating railway carriage springs, and the forging of small crank shafts and motor parts.

In this class of furnace, it is of great importance that the following conditions should be strictly adhered to or a waste of heat will result. The depth of furnace from back to front should not be greater than will suffice to allow of the forging to be heated to the necessary length, the height of the front opening should be only slightly larger than the material to be forged and just wide enough to allow of the right number of pieces to feed the hammer man. It is false economy to work with broken tiles. The right pressure of air must be maintained and this should never be less than ½ lb., prefer-

ably twice as much. It follows therefore that the blower must be equal to the maximum demand upon it and that the pressure should be positive. A fan is of no use for this work, a good rotary blower giving a maximum pressure of 5 lbs. is to be recommended, and this should be governed by a spring or weighted valve to give the right pressure. It is good practice to allow for 10 cubic ft. of air for every cubic ft. of gas consumed when arranging for the size of blower. An air receiver between blower and furnace makes for steadier work with the burners. It is advisable to have quadrant taps fitted to both gas and air supplies so as to aid in the proper regulation of the burners. Amongst file manufacturers, those using gas furnaces for forging are in the majority in the town, several of the largest makers employing gas exclusively for this purpose, and for the manufacture of agricultural implements one firm alone uses over 18,000,000 cubic ft. of gas annually. A similar type of furnace is also employed for heating machine knife blades, a lifting door being fitted to the front, and a flue at the back provided when used for such purposes.

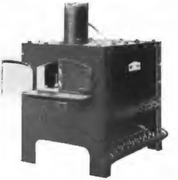


FIG. 5. PATENT REGENERATIVE GAS FURNACE.

Gas and air blast furnaces with the combustion chamber below the floor and the latter upon a level with the opening which is provided with a lifting counter-balanced door are in extensive use for hardening, and these are useful where it is not desirable for the steel to come into contact with the gas flame, and where large quantities of articles are being constantly removed and replaced by cold ones, as the recuperative power of such furnaces is very great. Crucible furnaces heated by the same method are often used for hardening twist drills, the crucible being removed and the heat obtained from the vertical cylindrical wall, the burner entering the bottom horizontally at a tangent to the circumference of the cylinder. Very even heating of the wall of the furnace is thus obtained, the drill being suspended vertically in the centre. This method of heating up does away with any tendency to warping on the part of the drill and the cutting edge is maintained in good condition.

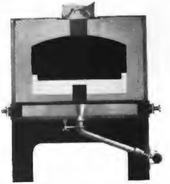


FIG. 6.—REGENERATIVE FURNACE SECTION.

Coming now to furnaces worked by gas at ordinary pressures with the aid of natural air draught only, these are mainly used in Sheffield for annealing work and this process has been rendered commercially possible by the following improvements upon previously made designs of gas heated natural draught oven furnaces. The first improved type is partly regenerative in action. It is strongly constructed of cast iron and mild steel plates and wrought iron, so put together that the furnace can be relined throughout by merely removing the top plate. It can be constructed in any size and absolutely

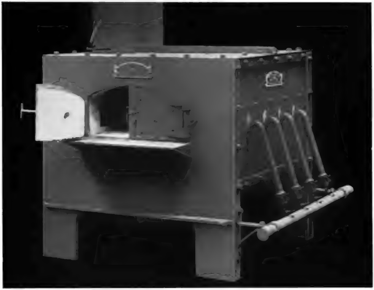


FIG. 7.—REGENERATIVE NATURAL DRAUGHT OVEN FURNACE BY THE RICHMONDS GAS STOVE & METER CO., LTD., WARRINGTON AND LONDON.

even heating all over can be relied upon. The bottom of the furnace is closed in with the exception of an opening running through the centre from front to back in which annular burners of a special design are fitted, these being placed at 9 ins. distance from their centres. Inside the annular ring of each burner is placed a fireclay cylinder with channels to admit secondary air required to complete combustion, which in its passage takes up heat from the cylinder. The burners are supported from a cast iron floor about 6 ins. below the furnace bottom, which is enclosed upon three sides. The floor of the furnace is made up of one or more tiles from 1½ ins. to 2 ins. in thickness, through which a large proportion of the heat from the burners is diffused, the remainder travelling up the side walls of the furnace through openings between furnace floor and sides. The flue pipe or pipes of comparatively short length have been carefully designed as to area, position and size of dampers in order to obtain an even pull from all parts, it being essential to have such adjustment that only the amount of draught necessary to obtain good combustion shall pass through the furnace The dampers are so made that air can be entirely excluded from the interior, which is, of course, a necessary condition in cooling down, when annealing steel. Temperatures up to 900° C. can be well maintained and relied upon for working with. A later design (see Figs. 5 and 6) which has been primarily constructed for steel annealing is fitted with burners having funnel shaped nozzles, which are introduced through the furnace bottom as in the other type, but which are entirely sealed up, admitting no secondary air from this part. Primary air and gas enter through the nozzles, the proportion of the mixture being adjusted at the mixing chamber of the burner. Supplies of secondary air are obtained

from adjustable ports introduced in both sides of the furnace, the passages being heated to a fairly high temperature, so that good regeneration is effected. The construction of the furnace in other respects is similar to that in the one previously described. The main results achieved by these modifications are that temperatures up to 1,300° C. can be obtained, thus rendering possible all kinds of hardening including that of high speed steel, also of heating through the furnace floor has been done away with in order to admit the employment of thicker and stronger floor tiles, the thin porous tiles of the other designs being admittedly their weakest feature. Besides this, it has been found that the time taken to heat up the furnace from cold is considerably shortened, temperatures are maintained at a very much reduced fuel cost and a higher maximum temperature is obtainable.

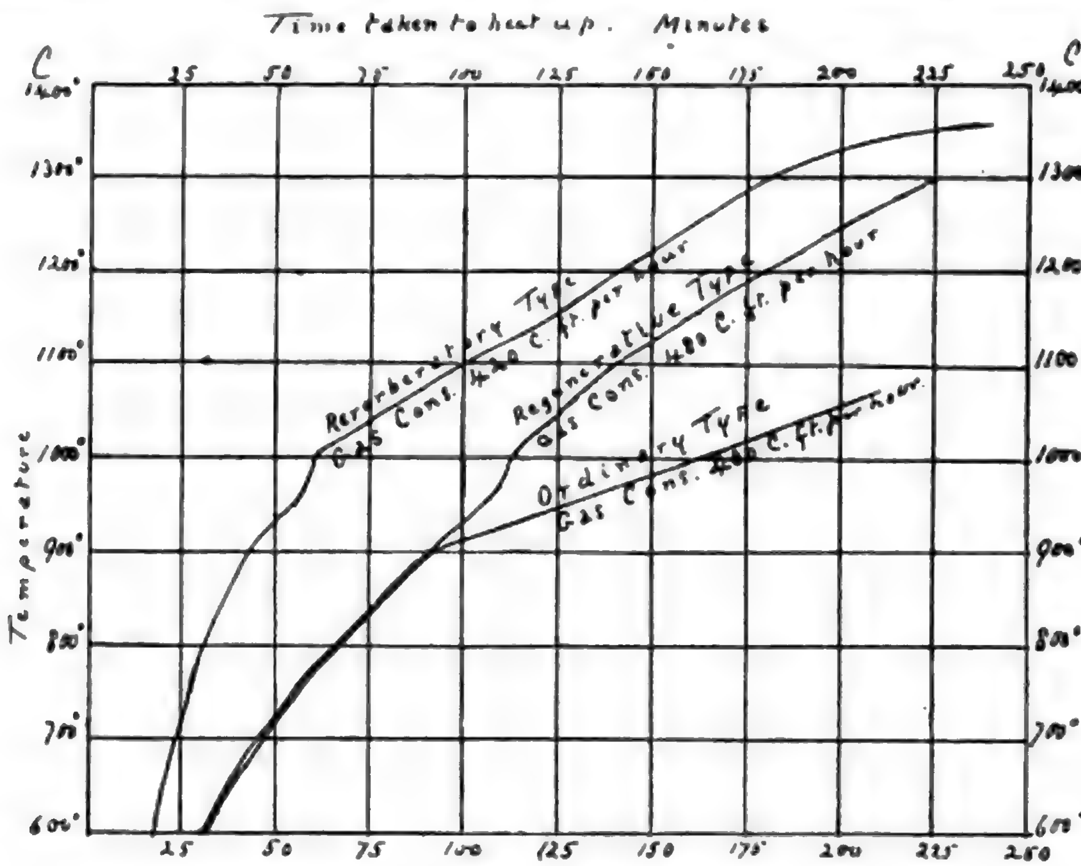



FIG. 8.—DIAGRAM SHOWING BY CURVES TIME TAKEN TO HEAT UP.

perfect control of the gaseous conditions within the furnace is possible, from a highly oxydising, to a completely reducing atmosphere; consequently, full advantage can be taken of those chemical properties of the constituents of town's gas which render it peculiarly suitable to the annealing of steel, of any composition. Further, the whole of the air inlets can be shut off during the process of cooling down the annealed steel.

Further improvement has just now been made in a new patented design of Messrs. Richmonds, Ltd., which is shown in Fig. 7. In this, the method These results are brought about by admitting gas and primary air through ports along one side of the furnace and the secondary air through heated channels up to these. The gas flames ascend the side walls, cross the arched roof and descend the opposite side, leaving through ports provided, into the flue. The flames do not contaminate any articles being heated, a pure radiant heat being given off which is even throughout from the floor roof and walls. The interior dimensions of the furnaces are the same, viz., 3 ft. long by 2 ft. wide by 1 ft. high to crown of arch. The tests

were made with ovens empty. The reverberatory furnace was found to maintain temperatures of 1,000° C. and 800° C. for gas consumptions of 175 cubic feet and 135 cubic feet per hour respectively. Fig. 8 is a diagrammatic curve showing the heating results obtained in the three different designs of furnaces.

Another advantage obtained by using a town's gas fired furnace is that the expense and trouble attendant upon the employment of a main flue and high chimney are obviated, no fluctuation of heats due to varying draughts can therefore occur.

Although the use of town's gas for annealing steel in any quantity is of comparatively recent origin, a large number of furnaces have already been supplied for this purpose, the capacity of the largest being for six tons. Two steel annealing furnaces are shown in Fig. 9. The most common size is one having interior dimensions, 15 ft. 9 ins. by 2 ft. wide by 1 ft. high, which is capable of holding over two tons of bar steel. Over 40 annealing furnaces have been erected and are now working in Sheffield, in many instances these are in duplicate, so that a continuous process of annealing can be carried out day by day, it being worthy of note that the time occupied in charging, heating, cooling and unloading is only 48 hours, as against the minimum period of three days for a coal fired furnace. No "coffins" are necessary in these furnaces. The following figures from an actual working test will show the economy of the process.

Details of charge :—35 cwts. best crucible cast steel carbon % ·80 — 1·45.

| | C.ft. | Actual Con. |
|---|---|---|
| Average gas consumption per hour, first 3½ hours .. .. | 1,555 | 5,445 |
| Average gas consumption per hour, last 2½ hours .. .. | 604 | 1,510 |
| | Total | 6,955 C.f. |

This works out at 3,075 c.ft. per ton.

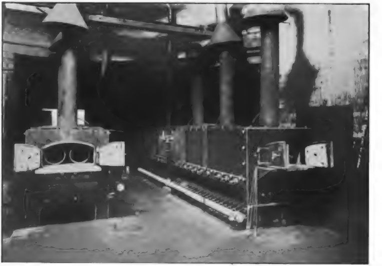


FIG. 9.—TWO ANNEALING FURNACES FOR STEEL BARS.

Cost for gas at 1s. per 1,000 c. ft. = 4s. per ton. Temperature attained, 770°C. The material was in the form of thick round bars, which required a good deal of soaking.

Molten lead and salt baths, able to maintain 800° C. as a working temperature, are in extensive use and these are mostly worked by low pressure gas and natural air draught, and they are employed in heating up for hardening files, various small joiner's tools, and some forms of cutlery. The size of the pots in use varies from 4ins. to 12 ins. diameter, by 12 ins. to 30 ins. in depth, interior dimensions. Other apparatus which is in common use for industrial work and which has been supplied and fitted up by the Gas Company, includes tempering plates, oil baths for tempering, file drying tables and ovens, core drying chambers, wire hardening furnaces by a continuous process, japanning and blueing ovens and covered hot-plates used for blackening bolts.

An account of gas furnace work in Sheffield would not be complete without mention of a unique and interesting furnace, burning town gas, designed and patented by Mr. Alleyne Reynolds, of Reynold's Steel Inventions, Ltd., for use by Messrs. Sanderson Brothers & Newbould, Ltd., of Sheffield (of which firm he is special metallurgical consultant), this being a tilting open hearth furnace holding about two tons of metal and is used at present for experimental work. The writer is indebted to the inventor for the following particulars of this furnace. It is provided with air regenerators of very ample dimensions, so that the waste gases issue at a little over 200° C. A powerful draught (up to 4 ins. water) is secured by means of a suction fan and the air supply is forced in by means of a fan also. In this way, complete independence of flues, with varying draughts, is obtained. An outstanding feature of the furnace is at once noticed when lighting up. A clean bright combustion takes place immediately. Ignition can be secured at a minute's notice and with such perfect safety that from the commencement frequent reversal can be made. A temperature of 1,760° C. in the same has been easily secured and with a 2 ins. gas supply at ordinary pressure, a flame 8 to 10 ft. long is easily obtainable. The inventor contemplates adding further improvements, including a device for securing correct ratios of air to gas under all conditions as well as a method of obtaining combustion in stages so that a less oxidising flame may be secured.

Although the cost of the calorie is higher *per se*, with this type of gas, than with producer gas, the absence of diluent nitrogen in the gaseous fuel enables regeneration (which is applied to the air only) to be carried to the utmost limit with cheap and non-complicated arrangements and comparatively very small ground space is required. Moreover, the advantages of absence of inconvenient coal stacks, attendant dirt and objectionable gas leakages render this form of furnace very advantageous for some purposes. Where the highest temperatures, such as steel melting, are not required, the furnace may be very rapidly brought to a working temperature and as gas inlets are small, they may be multiplied in number by branches from the main pipe, so that flames of uniform intensity and of indefinitely great length are easily securable.

Where such a supply of town gas is obtainable at reasonable rates, it will be found well worth while for manufacturers to go carefully into the question and to compare for themselves the relative advantages of using producer or town gas for these purposes.

# THE EVOLUTION OF THE SUBMARINE

**By Archibald Hurd**

IT is a significant fact that the British Admiralty are spending over one million sterling during the present financial year upon submarines out of a total provision of just over thirteen millions for new construction. The progress of the submarine, as an instrument for defensive and offensive warfare, has been exceedingly rapid and it is not without significance that the British naval authorities should already have limited their orders for torpedo boat destroyers and that the construction of torpedo boats for the British Navy has been entirely discontinued.

Strictly speaking the British type of under-water boat is not a submarine, but a torpedo boat of large displacement capable of moving on the surface or under the surface at will. From the very first British naval opinion strongly favoured the submersible type of craft. Even at the time when many French constructors were busy evolving a practicable submarine ship, British naval officers and the constructors at the Admiralty foresaw the possibility of combining the above-water and under-water craft in one type of ship, thus offering a considerable economy in money and men, while at the same time adding to the strategical and tactical strength of the Navy. These anticipations are now being realised, at least in part, and exceedingly useful vessels of large size, carrying the gun as well as the torpedo, and able to cruise either on or under the water, have been built.

In some quarters the development of the submarine has been regarded with suspicion and doubt—particularly the aim to secure a craft for use on or below the surface. Many naval officers and ship-constructors still favour the design of a special ship for each purpose of war. This was the peculiar feature of naval design during the Victorian period. Vessels were then provided for fighting with big guns or with light guns under varying conditions. The Navy had battleships of the first class for high sea operations, battleships of the second class which could easily navigate the Suez Canal, and coast-defence battleships, drawing very little water and therefore able to cruise inshore, and compensating for their limited radius of action by the heavy character of their armament. The last named were the type of ships specially favoured by the naval authorities of Germany, Austria-Hungary and other Powers which adopted a purely defensive policy.

There was also a variety of cruising vessels; some of them were given armoured sides and others had protected decks and were classified as belonging to the first, second, or third class in accordance with their size. There were other cruisers which carried no armour, besides sloops, gunboats, torpedo-gunboats, torpedo boats varying in size from 12 tons upwards, and we even experimented with a torpedo-ram, the famous *Polyphemus*. For every purpose of war it was then the fashion to design a special ship and many naval officers held in particular that the gun should be carried in one group of ships and the torpedo installed in another group. The

American Navy Department some years ago went so far as to abandon the fitting of torpedo tubes in battleships, determining to rely entirely upon the gun only in big vessels, leaving the other arm entirely to small, specially designed craft.

Very gradually, but very surely, one after another of the various types of special ships in the British Navy have disappeared. Only first-class battleships are now being built for the British Navy and even the battle-cruiser—the offspring of the armoured cruiser of the latter years of the nineteenth century—is now no more; she has been merged in the battleship which now, when oil fuel is employed, has a speed exceeding 25 knots. No country in the world is now building the great assortment of cruisers of various types with which we were familiar a few years ago. Indeed, very few cruisers are under construction. Naval strategists contend that they have now no use for anything except the scout-cruiser, ranging in displacement from about 3,000 tons up to 6,000 tons, the latter figure being that of the vessels which are being laid down under the new French programme. Thus naval constructors have evolved one type of armoured ship, carrying the gun and the torpedo, and one type of cruiser also armed with the two weapons.

Are we now on the eve of witnessing the adoption of a similar policy towards torpedo craft? It is suggested that all the various types are about to be merged into a new creation—the submersible destroyer.

This vessel will carry the gun as well as the torpedo. The British naval authorities were the first to determine to give submersible craft a gun armament. The experiment of mounting one weapon on a disappearing mounting proved a success and it has now been decided to equip all future submarines with guns as well as torpedoes, and thus in one hull will be combined the fighting qualities hitherto associated with the above-water torpedo craft of various types—but not the speed—and the submarine vessel.

The new British submarines of the "F" class, it is now known will displace about 1,200 tons—an advance of about 400 tons on their immediate predecessors. They will have a speed on the surface of 20 knots, and it is hoped to obtain a speed of rather over 16 knots when running submerged. These vessels will have six tubes for discharging torpedoes of the 21 inch type and will mount four quick-firing guns of three inch calibre. They will have a complement of twenty to thirty officers and men and will thus represent a great economy in *personnel* as compared with even the latest oil-burning destroyers, which have complements numbering about seventy. The whole tendency of naval development appears indeed to be in the direction of the reduction of the human element. The early destroyers of the 30 knot class, with a displacement ranging round about 400 tons, required crews of 60 officers and men, and in the Basilisk class, laid down under the Navy Estimates of 1908, the complement rose to 105. Now in the submersible destroyer, with four small quick-firing guns and six torpedo tubes, it is calculated that not more than twenty or thirty officers and men will be required, although these new vessels combine the fighting qualities of two distinct types of craft. The reduction of *personnel* in submarines is largely due to the introduction of a modification of the Diesel engine, which, still in its infancy, gives promise of still further development.

The submersible craft has come to stay and to develop because it is increasingly realised that the torpedo is a serious rival to the gun. Unless reports as to the achievement of foreign navies in torpedo manufacture are entirely misleading, the British authorities are in a position of considerable advantage in the development of torpedo vessels for the fleet under the new conditions. While there is probably no considerable difference in the capabilities of British and foreign guns, the British torpedo is believed to be the best in the world, and this advantage has become more marked since the introduction, three or four

years ago, of the new 21 inch type weapon first carried in the battleships of the *Hercules* type, with a greatly increased explosive charge and much higher speed. To what extent other European Powers have been able to take advantage of the development of the super-heater, which has given the new torpedo far greater range and speed, is unknown, but there is no doubt the British service has gained immensely from this invention. Probably the best testimony to this branch of the British service lies in the fact that the Navy Department of the United States has recently purchased a large number of weapons corresponding more or less closely to those used in the British Navy.

In recent years the torpedo has made remarkable progress, and hence the development in the design, both of destroyers and submarines in the past ten years. Admiral Twining, of the American Navy Department, directed attention to the change of opinion in the United States Navy in the evidence which we gave before the Naval Committee of the House of Assembly early in the present year. This officer made the following replies in answer to a series of questions :—

Q. : What are the largest torpedoes we are using ?

A. : 21 feet long, 21 inches in diameter.

Q. : Are not some longer than that made—are there not 24-inch torpedoes made ?

A. : No, sir ; there are nothing larger than 21 inches. There have been some longer than 21 feet, but nothing larger than 21 inches in diameter.

Q. : What is the range of these 21-inch torpedoes ?

A. : Some are designed for 10,000 yards range, and some for a shorter range, 4,000 to 5,000 yards, with a higher speed. They will do 5,000—well, to be conservative, say 4,000—at 35 knot speed, and are expected to do 10,000 yards at about a 27 knot speed.

Q. : That is the average speed ?

A. : Yes, sir.

Q. : They leave the ship at a much more rapid speed than when they arrive at the limit of their range, do they not ?

A. : The two types of torpedoes—the Bliss-Leavitt and the Whitehead—differ somewhat in that respect. The Bliss-Leavitt torpedo is operated by a turbine engine, and the variation in speed is not so great as in the Whitehead. We only allow a variation of, I think, half a knot or something like that. They get their maximum speed very quickly after they are started and keep it to the end until they stop. The Whitehead torpedo, of course, falls off a little more in speed.

Q. : We bought some Whiteheads abroad, did we not ? What did we pay for them ?

A. : That same torpedo bought abroad, exclusive of freight and duty, costs $3,297 (about £659).

Q. : You say the Whitehead torpedoes cost $3,297 exclusive of freight and duty ?

A. : Yes, sir.

Q. : What are we paying for the Bliss-Leavitt torpedoes, taking the same 21-inch ? They are making 21-inch torpedoes, are they not ?

A. : Yes, sir. The Bliss-Leavitt torpedo that corresponds most nearly in the range power and speed to that torpedo is an 18-inch torpedo, for which we pay about $5,800 (about £1,160).

These admissions of the power of the latest torpedoes explain the importance attached to its possession for warlike operations and the consequent increase in the output of submarine vessels to carry it.

It is only a few years ago since two of the most distinguished admirals of the American fleet held that the effective range of the torpedo at its maximum speed was only 800 yards and that, therefore, it was unnecessary to provide tubes in the new battleships then building "since the vessels could never expect to get within range for the use of this weapon." The credit for the change in American naval opinion is largely due to the research of the E. W. Bliss Company, of Brooklyn, who introduced a turbine-driven torpedo with a super-heater. Describing this new development some years ago in an American technical journal, when it first appeared, an expert writer described the Bliss-Leavitt torpedo as resembling the Whitehead torpedo in external appearance, while far surpassing it in speed, range and accuracy. Probably this claim, at the time, was justified.

The after portion of the torpedo, or the tail, contains in its forward end the engine which drives the propeller. The torpedo is operated by a turbine engine of the Curtis compound type, having two wheels, 11 inches in diameter, and each having 85 brackets. The wheels make 1,200 revolutions per minute. The engine develops 110 H.P. as against 35 to 40 in the "three-

cylinder engines heretofore employed. The remarkably high efficiency in speed and range of the new torpedo is due to the use of a superheating process applied to the compressed air. This consists of a flame which is automatically ignited the instant the torpedo is launched from the tube, and which burns during the entire run.

The regulation of the depth is effected by means of a vertical diaphragm, on one side of which is the water, which is allowed to enter by holes provided in the shell for that purpose, and on the other side a series of coiled springs, the water pressing against the diaphragm on the one side and the springs pressing the diaphragm in the opposite direction on the other side. The springs are adjusted so that their pressure shall exactly equal the pressure of the water at the given depth at which the torpedo is to travel. If the torpedo descends below that depth the water pressure, overcoming the spring pressure, pushes the diaphragm inwardly. If the torpedo is above the desired depth, the springs overcome the water pressure and push the diaphragm outwardly. The gyroscope wheel is a sphere of steel about as large as a baseball and weighing less than 2½ lb. If the torpedo tends to deflect to the right or to the left this gyroscope turbine maintains its original position, and its angular motion with regard to the torpedo (or to speak more accurately, the angular motion of the torpedo about the gyroscope) serves to actuate a mechanism which turns the vertical rudders to the right or left, and corrects the deviation.

Admiral Twining's evidence, already quoted, shows that considerable progress has been made in increasing the range and the speed of this torpedo, with the result that naval opinion on the other side of the Atlantic has undergone a radical change. The result of past policy in the United States is that at present of all the great navies of the world, the United States is the weakest in torpedo craft. Possibly this is partly due to the fact that this Navy has no narrow waters to defend or potential enemy near at hand, but, on the other hand, it has many harbours in which such vessels would be of the highest value.

As soon as the rumours of the new American torpedo reached England, experiments began with a view to an improvement of the type of weapon then used in the British Navy. The Whitehead Company succeeded in producing a heater which it is claimed is superior to any other. It consists of a small steel chamber between the air-chamber and the engine of the torpedo, in which liquid fuel is burnt in contact with the air which is passing through the engine. The apparatus is extremely small, taking up only about three inches of the torpedo's length, and it is light, weighing only about 12 lbs. The gain in power which has been obtained as a result of this development in its application to the familiar 18-inch torpedo is shown in the following statement :—

| | With Cold Air. | With Heated Air. |
|---|---|---|
| Speed at 1,000 yards | 35 knots | 43 knots |
| ,, ,, 1,500 ,, | 30 ,, | 40 ,, |
| ,, ,, 2,000 ,, | 28 ,, | 38 ,, |
| ,, ,, 3,000 ,, | 23 ,, | 32 ,, |
| ,, ,, 4,000 ,, | 18 ,, | 28 ,, |

The Whitehead Company have since adapted the heater to a 21-inch torpedo with a charge of 330 lbs. of explosive and an effective range, it is said, of 12,000 yards, and an initial speed of 48 knots. Details of the type of torpedo which is being made for the British service are regarded as confidential. There is, however, ground for believing that this weapon is superior in range, speed and accuracy to anything hitherto evolved abroad ; in fact, its range, it is claimed, is not inferior to the heaviest gun.

One has not infrequently to go abroad for information as to British naval developments and in the present instance it is *Le Yacht* which has published the most detailed particulars of the Hardcastle, or "service" torpedo, which is there compared to the Armstrong type, both of which are of the same diameter—21 inches. The following contrasts of the speeds at the several distances are supplied :—

| | Armstrong. Knots. | Hardcastle. Knots. |
|---|---|---|
| Up to 1,000 metres .. | 45 | 45 |
| ,, 2,000 ,, .. | 41 | 42 |
| ,, 3,000 ,, .. | 39 | 40 |
| ,, 4,000 ,, .. | 35 | 36 |
| ,, 5,000 ,, .. | 32 | 33 |
| ,, 6,000 ,, .. | 27 | 31 |
| ,, 7,000 ,, .. | 22 | 28 |
| ,, 8,000 ,, .. | 20 | 27 |

The writer in *Le Yacht* remarks that "Up to 5,000 metres—about 5,500 yards—there is little difference between the two torpedoes; the superiority of the Hardcastle type is revealed beyond this range, but it appears that the gyroscope with which it is furnished, though it can theorically direct it for 20 minutes, has not, it is said, given certain results for more than eight minutes; the effective range of the torpedo, therefore, has its limit at about 7,000 metres." This is a French opinion on the British torpedo, and it is confirmed by unofficial information in this country, such as Jane's *Fighting Ships*, which gives the Hardcastle torpedo a maximum range of 7,000 yards.

However this may be, the development is of a remarkable character, since in the Russo-Japanese war the distance which the torpedo could cover was only about 1,000 yards, at which it did not compete with the gun. It is now the gun's serious rival, and hence the increased attention which is being given to the construction of craft specially designed for its use and the decision, at any rate, of the British and German naval authorities, to increase the number of discharging tubes in large armoured ships. Whereas in the *Dreadnought* there were four submerged tubes on the broadside and one at the stern, it is reported that in the latest vessels the number is largely increased. In the British designed Japanese ship, the *Kongo*,—just completed at Barrow-in-Furness—the number is 8, all of them being submerged, and the most recently designed German vessels of the *Worth* class, of about 28,000 tons are, it is believed, to be provided with broadsides of six tubes with one in the bow and another in the stern, the whole eight being submerged.

The success which has been achieved in the improvement of the torpedo has powerfully influenced the decision of the British naval authorities to devote largely increased sums to the construction of large torpedo craft for offensive purposes, while still continuing to build smaller vessels for use on the coast. The course which the Admiralty are adopting was revealed by the First Lord of the Admiralty in a portion of his speech in the House of Commons, on March 26th last, when he explained that instead of laying down 20 destroyers, as in former years, it was proposed to begin only 16, but he added that this smaller number would be of a superior type and would cost as much as twenty vessels of the former programme. In other words these destroyers will approximate in size to small cruisers and will have a great radius of action.

In explaining the policy of the Admiralty with reference to above-water torpedo craft, Mr. Churchill remarked :—

> "The British torpedo-boat destroyer has been constructed with a double purpose. Its primary purpose is to cut down and drive from the sea by gun power the torpedo craft of the enemy. Its secondary, but not less important purpose, is to attack the great ships of the enemy's fleet by the torpedo. Both of these capacities of the destroyer is being intruded upon by other types.
>
> "The small, very fast cruiser, on the one hand, and the large submarine on the other, are making inroads upon both functions of the destroyer, and it is possible that future years may witness further reductions in the destroyer programme, to the advantage both of the light cruiser and of the submarine. It is with a view to preventing waste and loss to private firms, and giving ample notice, which will enable a gradual change to be made, that we are calling the attention to the destroyer builders

throughout the country to these possibilities.

I do not want to say very much about submarine construction. We have a very great superiority in numbers over every other country—excepting, perhaps, France—and we are providing over £1,000,000 this year for the further development of these very important vessels. The various types and sizes are being constructed in sufficient numbers, and the highly trained and experienced personnel, on which the utility of these formidable weapons depends, is being regularly and rapidly augmented."

These general remarks by the First Lord of the Admiralty seemed to point to the abandonment in the near future of the above water torpedo vessel in favour of craft which can be submersed at will. But the new submersible ship will have about one-third less speed on the surface than the destroyers which have been constructed during the past ten or fifteen years, and it is questionable whether full compensation for this will be found in the ability to sink beneath the water out of the range of possible attack.

It may be that, in dealing with a very technical matter, the First Lord went rather beyond his brief. At any rate there is no indication that the Marineamt holds any such view as to the immediate future. In announcing last year the decision to build six submarines annually for the German fleet in future, there was no suggestion of reducing the output of destroyers, which will be at the rate of 12 a year as in the immediate past. Nor does this amendment of the Navy Law stand alone as an indication of the policy of the German naval authorities. In the 1913 issue of *Nauticus*, it is remarked in this connection :—

It will be found, with the advance of technique, that the submarine will get, in greater measure than hitherto, the qualities which have hitherto characterised the torpedo boat and the destroyer of being able to go alongside other war vessels in the open sea. But even then the submarine will remain an auxiliary weapon as the torpedo is to-day ; sea power will always be obtained and kept by the power of battleships and cruisers. The submarine will generally have to do the same work by day as the torpedo boat—the destroyer—does by night ; as the dark makes possible the approach of the torpedo boat within discharging distance, so the submarine is placed out of sight and harm under the surface of the water.

The belief not infrequently expressed that the destroyer, in a very short time, will be superseded by the submarine is not to be considered ; for in the most important particular, the quality of the destroyer—its high speed—will never be obtained in the same degree in the submarine on account of its great weight and the unfavourable shape of the body of the boat. The idea of leaving high speed submarines to attack by night might perhaps be entertained in some circumstances, if it happened that all the fighting strength was entirely imprisoned at a particular time. The same idea is also advanced, however, concerning the use of the destroyer by day. The submarine and destroyer will remain side by side as sister weapons.

The peculiarity of the submarine weapon which it exhibits beyond any other fighting unit, is the capability to carry out an attack without great risk. The attack by a destroyer flotilla betokens a large demand on the battle strength ; a well led submarine flotilla, on the contrary will emerge from a successful attack without loss, the *personnel* strengthened by an increased belief in itself and in its weapon.

One cannot, therefore, in a comparison of strength reckon the number of the submarines on both sides without further consideration as in ships. More than in other weapons, there comes into the field of contrast the spirit of adventure, the military training of the personnel and the technical capability of the machinery.

Consequently for some time to come the destroyer and the submarine will both be constructed, and it is impossible to foresee with any exactness the precise line of progress in the immediate future.

It may be that the next development will come from the air, and that in the hydro-aeroplane, able to drop explosives, an antidote will at last be found to the devilish tactics of the submarine vessels.

As we have witnessed a contest between the gun and the torpedo, with the result that the two weapons are now mounted in every vessel in the Navy, so now we are on the eve of a struggle between the submersible vessel and air craft, and possibly—who can

say?—the distant future may produce a type of ship which can operate either on or under the water or in the air. This may seem to some persons an impracticable development, but the unimaginative shipbuilder in wood did not believe iron ships could be made to float and carry great weights; many naval officers used to scoff at the torpedo as impossible of development into a practical weapon of war; all aerial craft were quite recently regarded by many people as toys of no practical use. The metal ship, the torpedo and the aeroplane have all been pressed into the service of the great navies and the future may yet produce the aerial craft which, folding its wings, can travel on or under the water.

It is necessary only to point to the development of aviation as a branch of the naval service to silence sceptics. A few years ago there were few believers in England in the aeroplane as an extension of naval power and the airship was regarded with ill-concealed amusement, or amazement, at human folly as one disaster after another overtook the experimental vessels built abroad. Now the Naval Wing of the Royal Flying Corps has nearly a hundred hydro-aeroplanes with as many trained pilots; and stations are being created from the Isle of Grain right up the east coast to Cromarty. Orders have been recently given for ten airships of various types, rigid and non-rigid.

Practical business firms, such as Messrs. Armstrong, Whitworth & Co., and Messrs. Vickers, Ltd., are developing this new industry and sinking tens of thousands of pounds in the necessary mechanical equipment and in the construction of air sheds, costing about £60,000 each; the Admiralty are spending an immense sum on a double "dock" for airships in the Medway Valley, near to Chatham Dockyard, and plans are being considered for the construction of other sheds in other parts of the country, so that when the ships are ready there may be docks in which to house them. Crews for the airships are already under training, and at Whitehall there is an Air Department, under Captain Murray Sueter, whose name is familiar as the author of the standard work on submarines.

This represents the development of a little over a year in aerial matters, and who shall say that the immediate future, which may see the evolution of a submersible torpedo boat destroyer, will not also witness the development of a form of craft for war which will be able to cruise and fight either under, or on or over the sea?

# MODERN LAP-WELDED TUBE MANUFACTURE

By Chas. H. Wall.

LIKE a great many more manufacturers who have been wakened up by the example set us by the foreigner, the makers of lap-welded tubes in this country, especially the larger concerns, have aroused themselves and thought it was about time the old methods were left behind and that the race should be continued with the most modern methods against their foreign competitors.

The Americans were the first to bring their plants up to date by introducing machinery electrically driven and substituting the gas fired for the older coal fired welding furnace. With these two departures more mechanical means were substituted for the various operations as against the manual methods of the old style ; thus the new combination meant an increased output at a much less cost.

The writer would here like to state before describing this modern method that the most essential points to be studied in laying down a mill of this description are efficiency and quality, combined with quantity and economy : unless a new method can produce more of a better quality at a smaller cost no advantage is gained in adopting it.

The mill must be so arranged that raw material enters at one end, the finished article leaving at the other. To do this something on the following lines may be adopted.

An iron stores is provided for receiving the strips of the various widths and gauges as delivered from the ironworks, and as required for the various diameter tubes it is intended to make, the ground space being so divided to accommodate these sizes, each pen or stallage being marked with the size strip it contains. An electric overhead crane travels the whole length of the stores from which it can carry any size required to the next operation, viz., that of bevelling the edges of the strip, which is generally done on a drawbench. Two of these benches are placed parallel to each other—(see Fig. 1)—with tail beds or tables on to which the strip is delivered by the crane. The benches are wide enough apart to allow sufficient room for the strips to be stacked prior to going through the next stage.

The strip is bevelled by being drawn through and under two steel tools with knife edges set at the necessary angle for the required bevel. These tools are held in movable heads actuated by right and left hand screws to suit the different width strips. Near to the front end of the drawbenches is erected a gas fired furnace, the centre line of the bed corresponding to the centre line between the two bevelling or scarfing benches as they are sometimes called (see Fig. 1) ; this enables the furnace chargers to take up the strips from the floor and place them in the furnace to be heated ready for turning up. At the other side of this furnace is erected another drawbench known as the "turning up or skelping bench," the tail end of which is fitted with a table and turning up die and works adjacent to the furnace. (See Fig. 1.) The strip is heated to a bright red and drawn from the furnace in the flat into the die, being gripped by special shaped tongs, and is further drawn by the chain and turned up into a tube with the bevels over-lapping each other sufficiently to make the necessary weld. From this bench the skelps are passed on to skids, down which they roll into the welding pit.

From here they are passed into the welding furnace—(Fig. 2)—in the hot state. This furnace is gas fired and built parallel to the turning up furnace, the two furnaces thus being parallel and square to each other.

The hot skelp is taken from the rack by means of a swing lifted at the end nearest entrance to furnace the other end being seized with tongs by the furnace man, it is then lifted across and pushed into the furnace in which the bed is so arranged to receive three skelps lying parallel to each other, the centre one lying in a groove with the bevelled edges on the top side. At the other end of the furnace the welding rolls—(Fig. 2)—are erected and are brought as close as the bedplate will allow. A guide trough is fixed to the housings to carry and ensure the entrance of the hot skelp into the rolls as it leaves the furnace. From the welding rolls continues a trough, V-shaped, and at the end is a machine used as the bar stop and extractor; this machine runs out the mandril bar carrying on the end the welding plug; the length of this bar and plug are adjustable by means of a screw with a ratchet lever. The bar is driven by a pair of friction rollers, which are reversible. When the plug is in position, that is, lying between the welding rolls, the hinge lever is dropped into position as a stop to the bar. This ready, and the skelp up to welding heat, the welder uses a long rod forked at one end; this fork serves to catch on the end of the skelp. The other end of the rod is fitted with a T-handle, the welder with assistance pushes the skelp into the rolls through which it passes over the plug, drawn through by friction caused by the grip of the rolls on the metal supported from the inside by the welding plug. Running at a good speed the skelp is quickly carried through and welded; the tube now lies in the trough. The hinge lever is lifted, the bar pulling machine started the reverse way, the rolls by pressure of the foot lever grip the bar, extracting it from the tube; the tube is thrown from the trough by lever arrangement on to skids, by a reverse movement the welding bar is brought again into position with the welding plug ready for the next tube. As the centre skelp is pushed from the furnace into the rolls, one of the tubes at the side is rolled over into the groove and so the process of welding continues, one tube out, another in; the result is a continuous flow of tubes, the quantity averaging day by day from 1,000 to 1,200 of 2 in. tubes 18 ft. long every 12 hours.

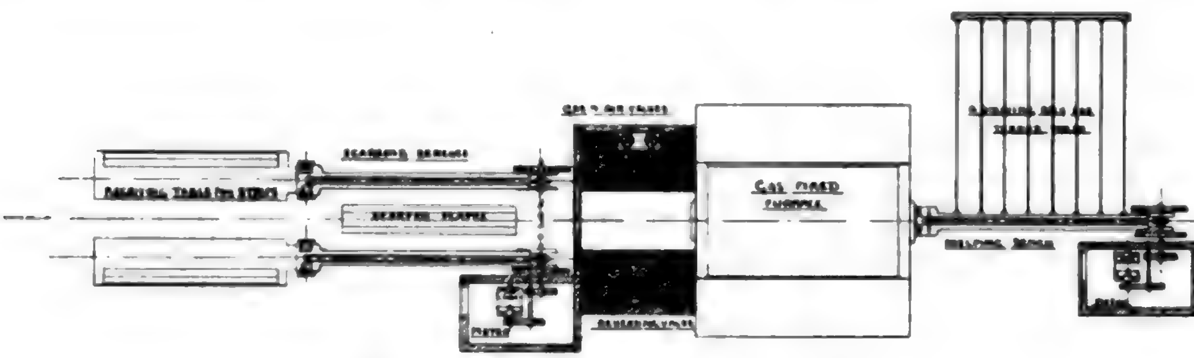


FIG. 1.—PLAN OF MODERN LAP-WELDING MILL.

After welding, the tube is rolled down the skids at the same time that it is examined. Should there be any facial defects discovered, or a bad weld, the tube is drawn off on to the floor to one side. If sound it is rolled into a trough from which it passes through sizing rolls going in an opposite direction from which it was passed through the welding furnace. The sizing rolls are carried on the same bedplate as the welding rolls, the bed being left long enough for this purpose and for the delivery trough from the sizing rolls to pass along and parallel to the side of the furnace. The trough being fitted

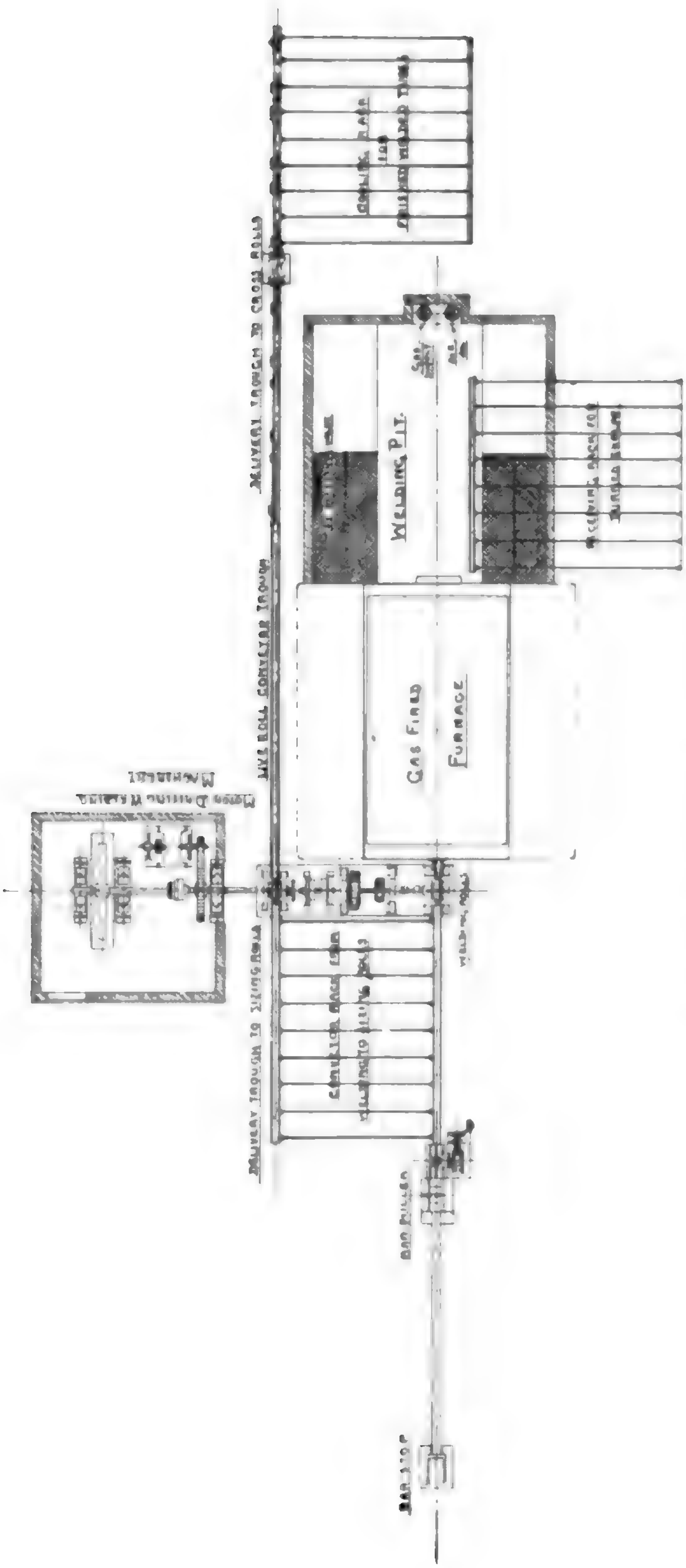



FIG. 2.—PLAN OF LAP-WELDING MILL—FURTHER PORTION.

with live rollers the tube is carried on mechanically towards the cross rolls through which it is passed into another trough. The cross rolls, besides straightening the tubes, clean off any scale from the surface, a supply of cold water running on to the rolls to effect this, thus giving a good finish to the tube.

The receiving trough from the cross rolls is fitted with a hinged lid properly balanced. This opened, the tube rolls out on to a skid at right angles to the direction it was going. The skid—(Fig. 3)—has plenty of room, holding a large quantity with free access of air above and below; the tubes quickly cool down. From this rack they are taken one at a time to be examined, and if not straight are made so in a springing block, the operator passing them on in quantities in cradles by means of an overhead electric crane to the screwing machines which may number half a dozen or more, these machines being of the open automatic type. The machines are so placed that one end of the tube is screwed by one machine, the opposite end by another, to avoid turning round, and thus saving time and labour. After screwing, the tubes are passed on to the proving benches for water testing under

a pressure of about 600 lbs. per square inch.

In the case of leakage due to a bad weld these are generally drawn down to a smaller size, heated to welding temperature for the operation, which makes them into a sound tube again. The sound tubes are marked by the examiner with a punch as a guarantee of their having been properly tested, and are passed on to the painters to be painted in their respective colours for steam, gas and water as the case may be.

It will be seen that in a properly arranged and up-to-date mill the material is delivered at one end ready for manufacturing into tubes, and by the various operations required the strip is carried forward from one to the other in rapid progression, each operation gradually changing its shape into the finished tube. Large quantities of tubes may thus be made with the minimum of labour, electrically driven machinery playing the most important part. Such a plant as has been described has an output of two to three times what could be produced by the older methods where the coal fired furnace, less machinery and more manual labour were used. No doubt the gas fired furnace is a great factor in an up-to-date mill especially with large firms who have orders at their commands to keep such plants running for say a whole week, day and night on one size; by so doing a great economy is effected and probably for this reason smaller firms cannot so well adopt it, they having to be content with the coal fired system which costs less to put down and with a corresponding production and less profits. It may be further noticed that in the up-to-date method each operation, due to the mechanical arrangement, lends itself to close inspection, and any defect being seen, the tube can be thrown out to save further expense. And with a properly balanced mill each turn's work is furnished and delivered into the warehouse within an hour of the last tube going through the rolls.

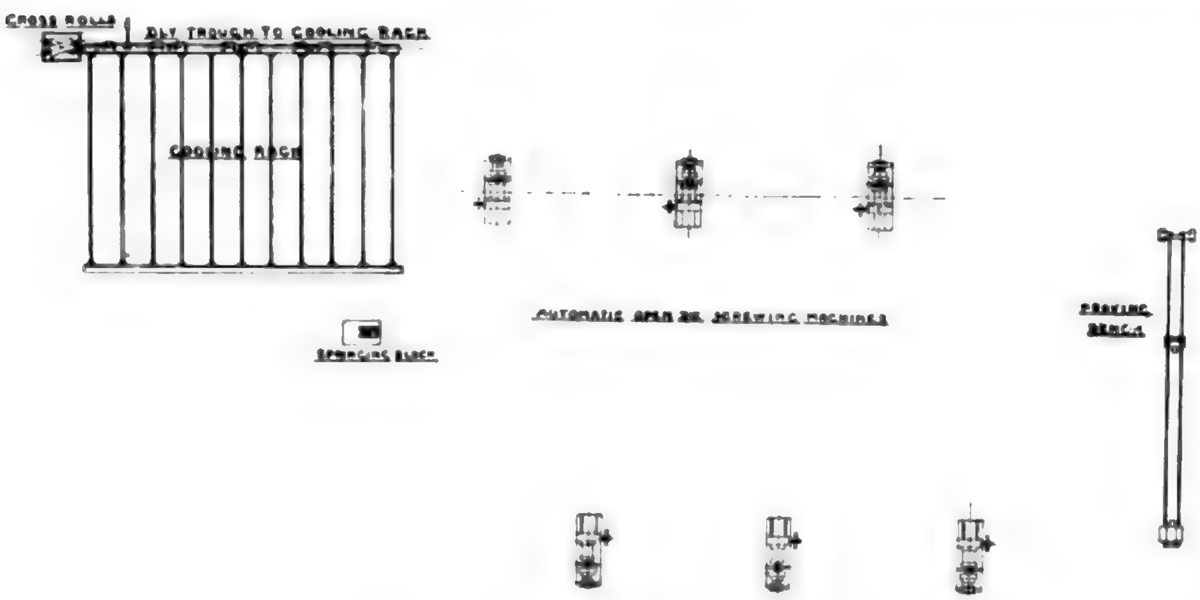



FIG. 3.—PLAN OF SCREWING MACHINES FOR LAP-WELDING MILL.

# ADVERTISING IN THE ENGINEERING TRADES

By G. Basil Barham, A.M.I.E.E.

IT would seem that to many firms in the engineering industry advertising must be an undesirable, almost unclean thing; something associated with blatancy, vulgarity and the blowing of one's own trumpet. It appears to be regarded in the light of being something which other firms might do, but which represents a level to which old-established and highly respectable engineering firms cannot descend.

By a small proportion of the remaining firms, advertising appears to be looked upon as a necessary evil, something remotely resembling blackmail on the part of the journals who hold orders for space until countermanded. The copy is seldom, if ever, changed, is generally anything but telling, and there is an unmistakable air of protest pervading the advertisement. There are other firms to whom advertising is evidently like putting on a clean collar; something which has to be done for the look of the thing, but which could very well be done without. They have no advertising manager, not even a youngster who is undergoing a course of training in one of the many advertising schools. The duty of writing copy is undertaken by someone who apparently passes it on to the man who locks up the warehouse after business is done for the day. The impression appears to be that any one who knows what the firm has to sell can draw up an advertisement; that one advertisement is as good as another; that there is no need to make an advertisement so attractive and forceful as to compel a prospective buyer to read it. It is certainly his business to find the advertisement for himself, and if he does not trouble to do that, or does not bother to read it when he has found it, why so much the worse for him!

There are many firms in the engineering industry who recognise fully the value of good advertising, who spend money freely in bringing their wares before the notice of users. They are open to take up and carry through any scheme, no matter how startlingly new it may be; the only question that enters into the matter is not "What will it cost?" but "Is it good advertising?" And there are other firms still, fortunately few in number, who employ an advertising manager, but carry out their own advertising; who say to the man they engage, "This is what we want you to do and this is exactly how we want you to do it. We have all the ideas we consider necessary in connection with advertising; all that you are to do is to carry them out!" It is therefore hardly to be wondered at that with the exception of a small proportion, the advertisements issued by engineering firms appear to have been drawn up in a far from attractive form. Some of them evidently have been written and laid out without any clear idea as to what was to be advertised or to whom the announcement was to be directed. It is in the advertisements which are presumably intended to appeal to those who stock engineering appliances or who make use of them in their work, that the weakness chiefly exists. The advertisement usually takes the form of a bald announcement giving the name of one or two leading lines, saying nothing whatever about them, their price or their merits, and concluding with the name and address of the advertiser. There is often no attempt whatever to point out to the retailer the business he may be expected

to do if he stocks the articles advertised; there is seldom any effort made to show the user the advantages he will gain. Firms who are in the habit of advertising in this particular manner should glance through the advertising pages of some American engineering journals and see how advertising to retailers and users should be done. In advertisements of a somewhat more advanced nature, there are signs of a desire to arouse interest. The goods are described as "Best," or "High Grade," or—somewhat timidly as if fearing contradiction —"Cheapest." There is occasionally an attempt made to give distinction to the advertisement, in which case large type or a weird arrangement of rules is brought into service. This at times results in the name and address of the firm being either left out altogether or so separated from the rest of the ad. as to appear either to be a small announcement in itself, or part of someone else's advertisement. It might as well be made clear here that the technical journals in which such advertisements appear are blameless in the matter. It is their province to set up the copy sent them in the way the firm want it done. They are at all times ready to assist their advertisers to draw up copy, but the trouble is that the engineering firms have strong ideas of their own; they rather resent interference and look upon any offer of the kind with suspicion; they feel they know their own business best.

As a general thing the advertisements addressed to retailers urging them to sell certain goods to the public are drawn up much better than those which urge engineers to make use of tools, materials or specific appliances of a patented or special nature. When advertising to the public it is evidently realised that something must be said regarding the good points of the article to be sold. Manufacturers appear to understand that the trade, generally speaking is the medium through which the public can be reached, and many of these advertisements are illustrated, and a fair proportion contain an abbreviated description of the appliance and an intimation that further particulars can be obtained by writing for them. But even these advertisements are frequently marred by bad setting; engineers as a body do not appear to realise that the use of a quantity of large type of the same or practically the same size is one of the greatest errors that can be made when drawing up an advertisement. Large type, the words crowded together, does not arrest the eye; it tires it. The letters run into each other, and the advertisement is difficult to read. The use of large type is to be deprecated; a statement that may be read with amazement by those firms in the engineering industry who apparently hold the idea which is acted upon by those who draw up music hall posters, that the greater the importance, the larger the type. Further, in such advertisements an effort is often made to call attention to a number of articles. The effect obtained is that of confusion; the advertisement looks flat, it does not stand out prominently before the reader in nine cases out of ten he misses it altogether. It is only a very small proportion of advertisers in the engineering trades who realise the value of good white space; who understand the value of meat and effective contrast. There are few things less attractive, less likely to catch the eye than an unbroken uniformity of lettering, whether it be large or small, heavy or light. At the same time violent contrast should be avoided. The contrast of large and small type is only permissible in full page ads. in a journal with a fair sized sheet. In half and quarter pages medium and small type, as neat and clear as possible, is what is wanted; otherwise the contrast is apt to be grotesque, and the advertisement is thrown out of harmony.

It requires a certain ability to draw up good telling descriptive matter, and the announcements of those firms who employ an advertising manager, or who give anxious thought to the wording of the descriptive matter they publish are easily distinguishable from the rest. Amongst the inexperienced there is a tendency either to high-falutin' or the exact opposite; the descriptions are either flamboyant, full of such

adjectives and expressions as "finest," "remarkably efficient," "highest possible standard of quality," "best possible materials under the most perfect supervision," and the like, or else they are terse and bald in the extreme. Incidentally it may be mentioned that of the two the latter are the more likely to be read even if the reading leaves the reader apathetic and unconvinced.

The drafting of an advertisement, especially one which contains descriptions of goods advertised, is work which requires literary ability, and in this the first thing necessary and the one thing that is essential is a good vocabulary. The repeated use of the same expression, or even of the same verb or adjective, wearies a reader. He may not be able to word the idea differently himself, but he recognises fully the other man's inability to do so. The possession of a good vocabulary does not mean that the advertisement should be worded in what may be termed "fine language," or that use should be made of fine resounding phrases. In trade adverts., as a matter of fact, plain simple wording is what is wanted. What is meant is that the writer should have an accurate knowledge of the King's English, of grammatical construction, should be able to write without using halting phrases, should have an instinctive knowledge of the most appropriate words to use and possess a sense of proportion which will prevent him wasting good expressions on unessentials, and thereby shrouding to some extent the very things which should be brought out most prominently.

It is with the advertising to the users of tools, appliances and materials that the principal waste of money occurs in the engineering trades, and it would almost seem as though a large number of the firms in the industry do not trouble their heads as to whether the advertising does or does not pay. It must be admitted that there is a difficulty in connection with engineering advertisements, or indeed with those of any other highly skilled and specialised trade, which does not obtain in the case of ordinary firms who advertise to the public. The difficulty is to trace results. The returns from the advertising in some particular journal, for example, a patent food or a billiard table can be ascertained with accuracy; the advertisement where the name and address of a firm is well known, it is useless to think of keying the ad. in any of the usual forms by giving a slight variation to either the name or the address, or asking for inquiries to be addressed to some particular department. Neither can the coupon system be adopted as few, if any, of the retailers in the engineering industry, who are themselves engineers in nine cases out of ten, would ever trouble to fill one up. A form of key that may sometimes be used is to give, in the advertisement, a distinctive title or description to a catalogue, which it is suggested should be applied for: "Send for list E.F. 41," for example. Even then, many replies will be received merely saying, "Please send catalogue," and it will be impossible to say whether the request is the result of the advertisement, or is merely due to the inquirer's sudden desire for a list from a firm whose name and goods he has known for some time. This latter is, of course, an example of the cumulative effect of advertising. The engineering firm should remember that good advertising is an investment that will bring returns until its capital cost has been repaid several times over. Even the effect of a bad advertisement is not necessarily lost; it is sometimes read and the name of the firm may linger in the mind. There are people in the engineering industry who say they are never influenced by an advertisement; consciously they may not be, but a good and attractive advertisement, well thought out, cleverly drawn up and properly set will have a lasting effect on the mind of the man who sees it, even if he refuses to read it, or neglects to give it a second glance.

# THE CHINESE AS ENGINEERS

By C. A. M. Smith, M.Sc., M.I.M.E.

IT is a fact beyond cavil that great changes have taken place during the last few years in the Far East. A political revolution has succeeded in China; an industrial revolution is commencing. During the five years since 1908 more changes have taken place in Canton—the most progressive city in China—than in the preceding 2,000 years. Western science has been introduced in the following practical manner: Electric light is obtainable, street scavenging takes place, there is a road wide enough for a wheeled vehicle, there is a railway near the city, and an airship has circled over the heads of the multitudes of dwellers in Canton.

If we come to details we can mention the introduction of reinforced concrete, internal combustion engines, electric motors, a great scheme for telephones, a project for electric tramways, the sudden disappearance of the queue (or pigtail), and the amazing fact that in a few weeks China discarded the old type of circular cap, and was re-hatted with European style felt headgear.

It is almost symbolical of what is happening out here—the Chinese merchant who walks along the road in a flowing skirt of gorgeous blue brocaded silk and a felt hat such as is seen in London or the Riviera.

That, however, is a change that is obvious to the visitor. But what is not so apparent is the fact that the Chinese engineer has arrived. For the last twenty or thirty years young Chinese students have been trained in the technical institutions of Europe and America. Many have also gone to Japan to earn scientific work. They have come to China—and China is beginning to agree with them that if the nation wishes to become anything but a cat's paw for others, then she must acquire a full working knowledge of twentieth century science. That is one reason why to-day we have palatial buildings and well-equipped laboratories in this Colony. The most "modernized" among the Chinese are from Hong Kong, and they have thoroughly welcomed the scheme which provides their sons with University education of the same calibre as that given in Europe or America.

There is another influence which has been affecting the Cantonese, or Southern Chinese. Hong Kong is, as regards tonnage of shipping, the greatest port in the world. In the magnificent roadstead ride the majestic liners of the P. and O. Company, and hundreds of other passenger and cargo steamers. As the size of the port has multiplied itself, the amount of repairs to be done has also increased greatly. And so, to the great surprise of the engineering visitor, Hong Kong has provided itself with some splendid docks and repair yards. The chief of these belong to the Hong Kong and Whompoa Dock Co. and the Taikoo Shipbuilding and Engineering Co. These yards are not only capable of shipbuilding, but marine engines and other types of modern machinery are built there. Speaking in quite approximate figures, some 8,000 to 10,000 hands are employed in the two establishments.

Most of the foremen are European, but the Cantonese is a mechanic by instinct, and requires but little instruction. In the naval yard a large number of fitters are also employed and in any of these engineering establishments they introduce the latest automatic machine tools without any anxiety.

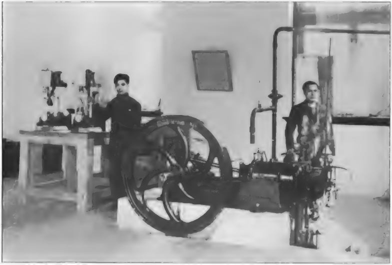
John Chinaman quickly tumbles to the new idea—very much more quickly than the average European.

Several of the more clever mechanics have commenced small engineering works of their own in, or near, Hong Kong. They have a courage and tenacity in their work which is amazing. A man of little or no financial resources will undertake to build a boiler for, let us say, a vessel over 100 ft. long. He obtains the plates, places them in the corner of a field, puts a mat-shed roof over them, and begins to build the boiler! For the life of me I find it impossible to explain how it is done, and it would certainly be futile to attempt to convince the reader that such a thing is at all feasible. No proper tools, no knowledge of the elementary principles, simply a wonderful memory which retains the picture of a boiler constructed years ago, and then—well, the Government Board of Trade Surveyor tests it according to all rules and regulations, and the amazing thing is that the boiler passes the test.

A few months ago the writer obtained the services of a Chinese mechanic from one of these dock companies. A little later the first portion of our engineering equipment arrived, namely, a Campbell oil engine. The mechanic had repaired steam engines, but had absolutely no knowledge of gas or oil engines. Yet he erected the engine. For a day he puzzled himself with the ring lubricators for the bearings. He was left to his own resources. After trying them in every conceivable place, he had an idea that they had some connection with either the valve or governor arrangements, but he finally put them in all right. And to-day the engine stands erected and in working order.

Patience, perseverance and a real mechanical instinct—those are the chief characteristics of the Cantonese. They are not perfect—nor is anyone. But they are wonderful engineers.

To-day China is awake; and what is of more importance, China contains



CAMPBELL OIL ENGINE RECENTLY ERECTED IN THE UNIVERSITY OF HONG KONG BY A CHINESE MECHANIC WHO HAD NEVER PREVIOUSLY SEEN AN INTERNAL COMBUSTION ENGINE.

iron ore. When the great Eastern nation works in iron and steel, as other nations have done—and there is every reason to be sure that China will do so—then the future will reveal some extraordinary changes in the might of that country as now compared with that of other great world powers.

From a slight knowledge of the Chinese character, the writer may be allowed to state emphatically that the whole world will benefit by the great awakening of China. For the sons of that nation will, at no distant date, startle the world with their valuable contributions to scientific researches. Only the ignorant fear the spread of knowledge. The progressive engineer will welcome the Westernisation of China for the huge stores of natural resources in that part of the world will enrich everyone in the world. The spread of applied science has taken the life of mankind out of a state of village outlook, and we are all of us aware that we are each year reaching nearer to a planetary, rather than a national, existence. We all of us hope that all nations will retain what is best in their traditions, but we cannot afford to forget that the prosperity of any one nation also means increased prosperity for all others. The Chinese engineer will add greatly to the material wealth of the universe by developing the minerals and water power of his native land.

## Current Topics

**International Electro-technical Commission.**

A MEETING of the above will be held in Berlin from September 1st to 6th. The Special Committees on nomenclature, symbols, rating of electrical machinery and prime movers, which have been working continuously since the Turin meeting of 1911, are to hold meetings in Berlin prior to those of the full Commission, in order to have a further opportunity of discussing the latest modifications to their reports, suggested by the National Committees. The result of these meetings will be embodied in the reports, which, thus modified, will be considered at Working Sessions of the whole Commission. When agreed to in their final form, they will be submitted to the plenary meeting for ratification.

It is hoped that at the official opening which will take place on Wednesday, the 3rd, a distinguished German official will present the address of welcome to the Foreign Delegates. A banquet is to be given by the German Committee the same evening.

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**Two Aerial Railways.**

"LE GENIE CIVIL" gives a description of the new passenger aerial railway which has been installed in the Tyrol, from Lana to the Vigiljoch mountain. These aerial ropeways afford a most convenient means of conveying ore, merchandise or passengers over ground where it is difficult to arrange transport by ordinary means. There are now seven passenger wire-rope railways in use or in process of construction ; one in France, from Chamonix to the Aiguille du Midi ; two in Switzerland on the Jungfrau massif, one to the Wetterhorn and the other to the Eiger ; one in Spain at San Sebastian ; one at Rio Janeiro, and two in the Tyrol, one on the Kohlerberg near Bozen, and the other from Lana to the Vigiljoch. Meran, one of the chief towns of the Tyrol has been connected for some years by an electric railway with the small town of Lana, a distance of nine miles. In order to increase the traffic on this railway an aerial railway has been constructed for tourists to facilitate the ascent of the Vigiljoch which overlooks the valley in which Lana is situated. This aerial railway was constructed by the firm of Ceretti and Tanfani, of Milan, and has been in service since August, 1912. The same firm is now installing the aerial railway at Chamonix. The Vigiljoch line is divided into two sections with one intermediate station, but the Chamonix line will have four sections. For purposes of equilibrium and for convenience of operation the cars are arranged in pairs, one ascending while the other descends, with a continuous motion between the stations. The length of the line from Lana to Vigiljoch is 1,877 metres, the first section being 905 metres long. The difference in level is 1,153 metres, that is 520 for the first section and 633 for the second. The cars are equipped with brake, catch and safety appliances and carry fifteen passengers each, including the conductor. Signalling and telephone appliances are provided to furnish means of communication between the stations and between these and the cars.

In the "Zeitschrift des Vereines Deutscher Ingenieure," for June 14th, Mr. Albert Pietrkowski gives a description of the new passenger aerial railway in Rio de Janeiro. This wire-rope railway consists of two independent sections, the lower from the city to the top of the hill called Morro da Urca. This line is 575 metres long and the difference of level between the lower and upper stations is 200 metres. The upper section begins at a station which is situated at a horizontal distance from the upper station of the lower section. This section conducts passengers to the top of the well-known Sugar Loaf (Paô de Assucar.) Its length is 800 metres and the difference of level between the two stations is, like that of the first section, 200 metres. Both sections consist of free hanging wire-ropes without any supports between the two extremities. The cars carry 16 passengers and the conductor. The railway was constructed by the firm of Pohlig and Co., of Cologne, and the first section began running on 27th October, 1912, the second or upper section beginning on 19th January, 1913. In February and March of the present year the number of passengers carried were 7,483 and 7,228 respectively. This heavy traffic has far exceeded the expectations of its enterprising owner and provides a substantial return for the capital invested. The city of Rio de Janeiro, which, from its situation on one of the most beautiful bays in the world, has recently been visited by a constantly increasing number of tourists, has also been furnished with another scenic attraction. The top of the Sugar Loaf or Paô de Assucar, which the aerial railway has now made accessible, commands a splendid view of the city and harbour with its numer-

ous islands. It was formerly quite inaccessible to the general public for only expert mountaineers dared attempt to make its ascent.

**Hope for Telephone Subscribers.**

PERHAPS a recent invention of Dr. Glover, of the Paris Conservatoire, may do something to obviate in the future the annoyance occasioned by frequent "wrong numbers" and other inconveniences arising from indistinct transmission on the telephone. The doctor in the course of his investigations on the human voice discovered that certain sounds, more particularly those containing the consonants M or N are really emitted through the nose, and not the mouth. These sounds can very easily be lost to the microphone of the ordinary telephone, which is, of course, covered by the mouth of the speaker, so Dr. Glover hit upon the idea of providing another microphone to receive the sounds emitted by the nose. According to "La Science et La Vie," the improvement in transmission was very marked in the tests that were carried out both over long and short distances, every syllable being distinctly audible. We submit this simple contrivance to the consideration of our own telephone authorities.

**Institute of Marine Engineers.**

BUILDING operations are now being begun on the Tower Hill site secured by the Institute for new headquarters more worthy of it. A total sum of £12,000 was required, of which £6,000 has already been subscribed, and it is hoped that the remaining £6,000 will be forthcoming during the current year, so that the premises, which will probably be completed in the early part of next year, may be opened with all financial obligations fulfilled.

As the annual income of the Institute is small in consequence of the comparatively low rate of annual subscription it has been found necessary to make an appeal over a wider area than that covered by the membership, but in view of the great services rendered to the Mercantile Marine as a whole by the Institute, we trust that this appeal will meet with the success it deserves, and that all interested in the progress of British shipbuilding will take this opportunity to recognise in a practical manner the valuable work performed by it.

Many shipping and shipbuilding firms have already subscribed generously, but further contributions are necessary in order to carry the scheme to a successful issue, and all donations will be gratefully received by the Committee at the old offices at 58, Romford Road, Stratford, E.

## CORRESPONDENCE

**Toothed Gearing.**

Dear Sir,—Referring to the letter of Messrs. The Power Plant Co., Ltd., in your July issue, on the subject of "Toothed Gearing," I quite agree that the excellent gearing put forward by that company may effect a saving in space and efficiency as compared with the ordinary type of double helical reduction gearing. The point I made, however, was that the double helical reduction gearing is more expensive than straight cut gearing, and this your correspondents have not disputed. I admit that I was not considering special types of gearing, such as the "P. P.", and that the adoption of such mechanisms is often advantageous in the long run, allowing a higher motor speed than would otherwise be permissible with a gear reduction.

If your correspondents will refer to the original article, they will note that I stated expressly that double helical gears can be run at very much higher speeds than straight cut gears, but I am sure they will agree that 1,000 ft. per min. is the safe all-round limit for the latter.

With regard to the Power Plant Co.'s remarks about ball bearing motors and the grooving of commutators, I would point out that the use of ball bearings for large direct current motors has not proved altogether satisfactory in practice, and this type of bearing is now generally confined to motors of 4 or 5 H.P. and less, and

then by no means to the majority of machines. In such small size motors the brush pressure on the commutator, and the currents carried, are so small that grooving is not serious. In this connection, one large electrical concern built a considerable number of ball-bearing rotary converters, but has now dropped this practice. Without ball bearings they are able to fit a shaft oscillating device for the express purpose of eliminating grooving. Without some freedom of axial movement, even though the brushes are staggered, a certain amount of grooving is unavoidable outside the brushes, and although it may be reduced by proper care and attention, it is unfortunately the fact, in practical operation, that engineering machinery does not always get the attention it deserves by a very long chalk. It is, therefore, necessary to take every precaution to prevent possible troubles by features in the design.

Whilst the Power Plant Co. undoubtedly put forward a sound speed reduction proposition, in view of the facts of the case as they have been brought home to me by many years' experience in industrial electric motor applications, I still think that a large slow speed motor direct coupled to a line shaft gives the best all-round results, especially in the case of direct current or a.c. commutator machines. Of course, where large speed reductions are necessary I freely admit that "P. P." and similar apparatus will often be far the best, but in my article I had in mind the ordinary case of speed ratios of about 4.5 to 1 and less.—Yours truly,

THE WRITER OF THE ARTICLE.

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# BOOK NEWS

### All the World's Aircraft, 1913.

By Fred T. Jane. Sampson Low, Marston and Co., Ltd., London.

Just as "Jane's Fighting Ships" is the standard work of reference for international naval information so "All the World's Aircraft" has become the recognised medium of aeronautical intelligence. It is arranged somewhat on the lines of "Fighting Ships," but is divided into four parts. The first deals with the aeroplanes and dirigibles of the various countries in alphabetical order. This section contains a list of Aerial Societies, Aerial Journals, Flying Grounds, private and military aviators and, of course, details of aircraft built and building, including wherever available photographs and plans of the machines.

The second section contains illustrations and particulars of "Historical Aircraft," that is to say of all craft notable for special achievements or peculiarities of design during the last six years. Part three includes specifications and photographs of the world's aerial engines, and part four is an aerial "Who's Who" and directory. A useful glossary of technical terms in five European languages is also given. In the preface Mr. Jane draws attention to the revival of interest in the dirigible, and the extinction of the idea that it could only exist at the expense of the aeroplane. It is now realised that both are interdependent, and each have their separate uses. He considers, however, except as a war machine, the aeroplane is of little use, so the pendulum has really swung the other way. In regard to the military aspect special stress is laid on the necessity of having first of all firms able to turn out aeroplanes in large numbers, and secondly a large reserve of trained aviators. It appears that merely civilian aviators will not be of much use for war purposes; some military training is essential. It must be remembered that one month is probably the utmost limit of the effective life of an aeroplane on hard active service; properly equipped firms capable of turning out efficient machines cannot be improvised on the spur of the moment, hence the necessity of developing the resources of the country in this direction. Given the firms and plant, machines can be turned out very rapidly. Bearing in

mind the fact that the use of aeroplanes is practically confined to military purposes, and that the demand is therefore necessarily limited, it is essential that the Government should do all in its power to encourage the development of such firms as we have mentioned.

In the present edition certain improvements have been made, notably the abolition of the old arrangement of separately grouping monoplanes, biplanes, etc. There is, however, one further improvement we would suggest, the provision of a thumb index as in "Fighting Ships." The volume, as we have said is a standard work and, of course is indispensable to all those needing data on this vitally important subject.

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**A Manual of Marine Engineering.**

By A. E. Seaton, M.I.C.E., M.I.N.A., M.I., Mech.E., &c. 17th edition, revised and enlarged. Charles Griffin & Co., Limited. London, 1913. 28s. net.

In the 17th edition this most excellent text book has been brought right up-to-date, and contains all the latest marine engineering theory and practice. The work embodies a mass of information on the various types of marine engines and boilers, and should be of great practical value, both to the advanced student, and to the engineering profession in general. The various rules and formulæ are given in a most concise manner, and the required explanations are very clear. A great feature of the work in the section devoted to the various auxiliaries fitted in warships. This feature, in many engineering works, has not been given the consideration its importanee deserves. When it is considered that the many auxiliary engines fitted in these vessels play as equally an important part as the main propelling machinery of the ship, this section should prove of great interest to all connected with naval engineering. The oil engine is dealt with, and the advances made in this type of prime mover are discussed. In the turbine section, the combination of the reciprocating engine and the marine turbine, as the ultimate economical combination for war and merchant ships, is duly considered. The various types of torsion meters are also fully dealt with. The part dealing with the efficiency of the component parts should prove of great interest. A valuable asset of this book is the section containing the various rules and formulæ for machinery and boiler tests now adopted by the various countries. The illustrations, of which there are a great number, are excellent, enabling the text to be followed with much greater rapidity. The whole production reflects great credit on its gifted author.

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**Heating Systems. Design of Hot Water and Steam Heating Apparatus.**

By F. W. Raynes. Longmans, Green & Co., London, 1913. 10s. 6d. net.

This book embodies the most modern practise on the particular branch of engineering with which it deals. The various systems of steam and water heating such as exhaust steam, vacuum and vacuo vapour are fully described and excellently illustrated. There is a chapter devoted to a more general view of the question of heating and ventilation, while another deals with heat losses from buildings. The economic aspect of the various methods is carefully gone into, more especially in connection with the heating of works and other industrial buildings, and the practical rather than the theoretic side of the subject is emphasised throughout, for though much of the matter is necessarily technical, the work is intended for business men as well as engineering students. An appendix containing tables of data and a full index conclude this useful volume.

## SHIPBUILDING AND MANUFACTURING NEWS

**H.M.S. "Queen Mary."**

WE give below a photograph of the latest completed battle cruiser. She was built by Palmer's Shipbuilding & Iron Co., Ltd., of Hebburn-on-Tyne, and her dimensions are as follows:—Length, 660 ft.; breadth, 89 ft.; mean load draught, 28 ft.; displacement at load draught, 27,000; coal capacity, 1,000 tons. She has an estimated horse power of 75,000, and attains a speed of 28 knots. The powerful main armament consists of 8 13.5 in., and 16 4 in. guns. The trials of the vessel, which have recently taken place, were entirely satisfactory, all the contract conditions being fully complied with.

H.M. BATTLE CRUISER "QUEEN MARY," BUILT BY THE PALMER SHIPBUILDING CO. LTD., HEBBURN-ON-TYNE.

**The "P.P." Safety Shot Firing Appliances.**

The "P. P." safety shot firing appliances had their origin in an accident resulting from a misfired detonator. In clearing debris the wires were struck by the point of a pick which exploded the detonator and charge, and a fatality resulted.

The two inventors, Messrs. Abraham Price and William Pryse (both operatives of more than 20 years' experience in the pits of the Ocean Coal Company, Ltd., Treorchy, South Wales) who were related to the unfortunate victim of the accident, set themselves to devise a means whereby a misfired detonator might be with safety withdrawn from a shot-hole and a fresh one substituted to fire the original charge. In achieving this end by means of the detonator shield and charging appliance described below it is claimed that three further results have been accomplished, namely :—

1. By making it possible to insert a detonator into the shot-hole after the hole has been rammed, the main cause of misfires, the destruction of the insulating material on the leads of electrically fired detonators, has been eliminated.

2. Elements of danger have been removed from all the processes leading up to the firing of a shot. The detonator is enclosed within a shield at the factory where it is made and cannot be injured or exploded by rough handling. Moreover, it becomes unnecessary to handle an explosive cartridge with a detonator in it, whilst the ramming of the charge is more safely carried out in the absence of the detonator.

3. The rending efficiency of high explosives is increased in shot-holes charged by the "P. P." method which provides an annular air space in the tamping. This makes for larger and less friable coal.

Should a misfire occur (and serious accidents are from time to time recorded as a result of misfires) the advantages of being able to withdraw a faulty detonator which has missed fire from a shot-hole and to insert a fresh one are obvious, the necessity of boring a second hole adjacent to the misfired hole being eliminated and the loss of time in searching for a misfired detonator and charge in the debris of the second hole, a process which is not only wasteful of time but dangerous to the worker, is avoided. Under the "P. P." system each detonator is enclosed at the factory in a shield slightly larger in diameter than the cap and arranged so that any strain applied to the detonator leads is received by the shield.

The charging appliance consists of a hollow tube marked with a graduated scale on the outside for measuring the depth of the hole, through which tube passes an inner rod, to which a loose copper spike is attached. The spike, which protrudes from the forward end of the appliance, is inserted into the priming cartridge which, together with the appliance, is placed in the shot-hole. The hole is now rammed and then by withdrawing the internal rod, which brings with it the spike, a shielded detonator can be inserted through the hollow tube into the hole left in the primer by the withdrawal of the spike. Small springs on either side of the shield retain it within the cartridge while the appliance is withdrawn. The mouth of the hole having been closed to exclude air, the shot is ready for firing. The annular air space left in the ramming by the withdrawal of the charging appliance tends to convert the shattering force of the modern high explosive into a rending action and, at the same time, makes it possible for the shielded detonator to be withdrawn from the hole by the application of a pull of sufficient strength, say about 8 lbs., to cause the small springs on the shield to give way within the cartridge. After withdrawal of the detonator the charging appliance can be again inserted into a shot-hole and a further cap put into the primer.

Demonstrations under working conditions have been given in coal mines and quarries, and the appliances have been demonstrated to a large number of important mining engineers and managers, and in all cases complete satisfaction as to their safety and

practical efficiency has been expressed. Further, the use of the appliances has been witnessed by representatives of the Shot Firers of the United Kingdom and by several district associations of officials, and resolutions in favour of the adoption of the appliances have been passed.

Official trials are now in progress at the Bishop Middleham Quarry of Messrs. Pease and Partners, Ltd., Ferry Hill, Durham, where H.M. Inspectors of Mines are keeping observation of the use of the appliances under working conditions with the view of modifying the statutory rules governing blasting to permit of their use in the English coal mines.

### Coal Handling Plant.

The list of recent orders secured by Ed. Bennis and Co., Ltd., of London and Bolton, is an imposing as well as a very comprehensive one, for contracts have been filled in all parts of the country. To enumerate them in full is impossible in the space at our disposal, but one or two will serve to indicate the success which the Bennis stokers and furnaces are continuing to achieve. Moreover, the fact that a large percentage of these orders are "repeats," proves in itself the satisfactory nature of their performances.

Railway companies are represented by a northern line which has ordered two Bennis stokers, with self-cleaning compressed air furnaces. Messrs. Clark, Chapman and Co., Ltd., the well-known general and electrical engineers, of Gateshead-on-Tyne, have been supplied with a set of soot removing gear to suit two Woodeson boilers. Machine tool manufacturers are represented by Greenwood and Batley, Ltd., of Leeds, and Municipal Corporations by the Southend Electricity Department, which has installed a complete plant, consisting of bucket elevator, chain conveyor, coal storage bunkers, etc. Further afield is the Toronto Water Works, Canada, where three new link chain grate stokers have been fitted. Among the other customers are, steel, asbestos, oil, and paper manufactures, laundries, spinning mills, and indeed almost every phase of industry figures in the list.

### Road Construction.

The constant extension of motor traffic, necessitating a wide departure from previous practice in road construction and maintenance, has created a large field for work of this character. A new Company—Highways Construction, Ltd., has recently been registered to work the Praed patents for the construction, maintenance and repairs of roads in this country. The offices of the new Company are at Finsbury Court, London, E.C., the directors being:—Hon. B. C. Pearson (Chairman), Mr. H. F. Berry, Mr. H. H. Goldney, Mr. J. Purdy, Mr. C. W. Sharrock, Mr. V. S. Wright. The staff of the Praed Road Construction Co. has been absorbed into the new organisation and it will undertake the construction of roads on the asphalt macadam principle, which has been such a successful feature of the operations of that Company. The material to be used by Highways Construction, Ltd., is the high grade bitumen which is already well-known to surveyors and road engineers generally under the registered name of Mexphalte. This bitumen represents the finest material known to science for the construction of dustless, waterproof roads capable of standing the severe stresses of modern motor traffic, and as it is being regularly imported on a large scale by the Anglo-Mexican Petroleum Products Co., Ltd., there will be no limit to the supplies of material or to the extent of the work with which Highways Construction, Ltd., will be able to cope.

Maurice Sylvester Gibb began his technical training as an apprentice with the Central Marine Engine Works, West Hartlepool, of which firm he is now Managing Director. After serving his apprenticeship he gained experience afloat as an engineer on the steamers of George Thompson and Co. (Aberdeen White Star Line) and then became Outside Machinery Superintendent to the North Eastern Railway. In 1907 he returned to the Central Marine Engine Works (makers of Marine Engines and the well-known "Cmew" Steamship Auxiliaries), as General Manager, and in the early part of this year was appointed Managing Director. He is a member of the Institution of Mechanical Engineers and a member of the Council of the North East Coast Institution of Engineers and Shipbuilders.

MAURICE SYLVESTER GIBB, M.I.MECH.E.

See reverse side.

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# THE GAS TURBINE

By L. Ventou-Duclaux, E.P.C.

THE production of mechanical energy is at the present moment an object of continual research, and the advances made are following each other with remarkable rapidity. We live too near present developments to be able to appreciate properly the characteristics of their evolution; still we can to some extent even now forecast the future of the construction of gas engines.

It is possible to lay down the two following propositions with respect to the technics of gas engines:—

1st. For a given power, there is a constant tendency for the gas engine to become lighter, that is to say, the ratio of its weight to the horse power it is capable of producing tends to diminish.

2nd. The gas engine by its cyclic regularity tends to resemble the electric motor in its conditions of working.

The weight per horse power is by its definition the quotient of two quantities. If it be desired to diminish this quotient, either the numerator must be decreased or the denominator increased.

The two methods of attaining this object are to increase the amount of work which a cylinder of given capacity can produce, or to diminish its mass. If weight is the important factor in industrial or marine applications of motive power, we will never be able to cope with it in the same way as it is possible to do in the realm of aviation. Indeed, aviation has been made possible only because improvements in the production of motive power have resulted in the invention of the light gas engine.

Since diminution of weight is a fundamental necessity in the case of gas engines for aviation, it is by studying this class of engine that we can appreciate more readily the efficiency of the different methods at our disposal.

The gas engine whose motive power is an explosive mixture, acts by intermittent force or impulse. These impulses may be more or less violent, and if one of them suddenly fails the equilibrium between power and resistance is abruptly disturbed. Since the flywheel has now been generally discarded, this abrupt disturbance of equilibrium may cause a serious breakdown.

The light gas engine, therefore, must be one which acts by continuous impulse, and the force of this impulse

must be strictly limited. At the present moment the best results directed towards the reduction of the ratio of weight to horse power, have been obtained by diminishing the mass of the gas engine.

But in order to effect this reduction of mass the question arises whether we should do so by diminishing the weight of its parts or by trying to arrange a special combination of those parts. It is in this direction that progress may be expected, and it is to this method that we can trace the happy idea of gas engines with rotary cylinders.

This line of reasoning enables us to recognise the importance of the method of continuous impulse, which ensures the regularity of the cycle. It also enables us to draw a conclusion respecting the great improvement which results from a special disposition of the parts of the gas engine.

These two considerations lead us to the continuous combustion turbine, and later on we shall bring forward still further arguments in its favour.

Let us now consider which cycle is most advantageous for the gas turbine.

The following table gives the figures which indicate the thermal and mechanical efficiency for each of the cycles which are applicable to gas turbines, the final temperature of expansion being brought to 700° C. on the absolute scale.

that the mechanical efficiency can be improved, and that is in itself sufficient to justify the importance of the gas turbine.

The isothermal combustion cycle would involve excessive compression, and it may therefore be disregarded.

The cycle with combustion at constant volume gives, with the same initial compression, a higher efficiency than the cycle with combustion at constant pressure, but the absolute degree of efficiency is not higher, because the limit of the admissible maximum of the temperature of combustion is reached more rapidly. The principal advantage, from the standpoint of its application to gas turbines, consists in allowing the employment of a less important compressor, and this advantage would be specially interesting if we could be satisfied with purely rotary compressors. In practice, the mechanical efficiency would be low, because of the losses due to the variable flow of gas which is the result of the explosions. As a consequence, the turbine with discontinuous combustion only appears to be indicated in the case of low powers obtained without preliminary compression and for light engines in which the efficiency is only of secondary importance.

The cycle with combustion at constant pressure (Diesel cycle), with isothermal compression, would then

| Compression Ratios | | 5 | 10 | 15 | 20 | 25 | 30 | 40 | 60 | 80 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Thermal Efficiency.** | | | | | | | | | | | |
| Gas Engines with discontinuous combustion. | Cycle with combustion at constant volume — with adiabatic compression | 0.505 | 0.595 | 0.645 | 0.654 | | | | | | |
| | — with isothermal compression | 0.51 | 0.61 | 0.66 | 0.68 | | | | | | |
| Gas Engines with continuous combustion. | Cycle with combustion at constant pressure. — with adiabatic compression | 0.37 | 0.49 | 0.54 | 0.58 | 0.63 | | | | | |
| | — with isothermal compression | 0.36 | 0.45 | 0.49 | 0.53 | 0.54 | 0.56 | 0.59 | 0.63 | 0.65 | 0.67 |
| **Mechanical Efficiency.** | | | | | | | | | | | |
| Gas Engines with discontinuous combustion. | Cycle with combustion at constant volume. — with adiabatic compression | 0.38 | 0.34 | 0.32 | 0.30 | | | | | | |
| | — with isothermal compression | 0.52 | 0.54 | 0.55 | 0.56 | | | | | | |
| Gas Engines with continuous combustion. | Cycle with combustion at constant pressure. — with adiabatic compression | 0.16 | 0.16 | 0.15 | 0.15 | 0.15 | | | | | |
| | — with isothermal compression | 0.36 | 0.39 | 0.42 | 0.44 | 0.445 | 0.45 | 0.47 | 0.49 | 0.51 | 0.52 |

From this table we see that high thermal efficiency is compensated for by low mechanical efficiency. Note

appear to be the most advantageous for the gas turbine. So long as the ratio between the extreme pressures

has a constant value, it is immaterial whether the absolute values of these pressures are low or high; it is therefore important to produce an exhaust at low pressure and thus the application of multicellular compressors is facilitated.

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Before dealing with the question of the production of energy and considering how this fundamental portion of the problem has been studied and solved, let us deal briefly with the utilisation of the kinetic energy which is produced.

Let us consider an enclosed space in which the explosion or combustion of a gaseous mixture takes place and the products of combustion are directed against vanes which are designed to receive their kinetic energy.

Here, as in steam turbines, we may draw a distinction between "action" turbines and "reaction" turbines.

In "action" turbines the fluid is completely expanded before coming into contact with the vanes, on which, consequently, it acts when it has attained its greatest velocity. In this case the fluid acts in the same way as water in a hydraulic turbine.

In "reaction" turbines, the kinetic energy is utilised at the very moment of its production. In this kind of machine the fluid never attains so high a velocity as in action turbines. In this case it is necessary to employ a system of wheels in order to collect the work done, for the expansion has to take place within the turbine itself.

However, this method of utilising the kinetic energy does not constitute a characteristic difference between the two classes of engines, because the action turbine often admits of combinations of vaned wheels. They are then termed multiple action turbines in contradistinction to the name "simple action" turbines which is applied when the fluid only acts upon a single vaned wheel.

Let us now examine the question of the flow of motive fluid at the outlet of the combustion chamber. As in steam turbines, this flow takes place in the tubes which direct the motive fluid on the vanes.

The experiments of M. Stodola showed that if the pressure of the fluid in the combustion chamber is subject to variations (as is the case in turbines with discontinuous combustion) sound waves are produced. These waves, however, are only produced if the velocity of flow at the outlet is greater than that of sound, that is, 330 metres per second. The production of these waves involves a considerable loss of energy.

On the other hand, if the pressure of the fluid is higher than that which would correspond with the outlet section of the nozzle, an abrupt impact is produced, and the pressure curve exhibits a protuberance followed by considerable undulations. If the counter-pressure increases to such an extent as to reach the same order of magnitude as the pressure in the interior of the chamber, the protuberance enters deeper and deeper into the nozzle and may even reach the neck. This phenomenon is likewise accompanied by a very considerable loss of energy.

The study of these phenomena leads to the following practical conclusions:

In order to effect an adiabatic expansion from $pT$ to $P_1 T_1$, a nozzle of definite length must be used. If it be too short the expansion will be incomplete and the kinetic energy produced will not correspond to the whole of the energy to be disposed of. If it is too long a shock will result as well as vibrations accompanied by a loss of kinetic energy.

Experiment alone can determine the proper length. To do so, the pressure is varied, and its most favourable value is found.

It is thus seen how difficult it is to obtain a high efficiency in the case of a turbine with discontinuous combustion in which p and T vary with each explosion and whose nozzle in consequence is periodically too short and too long. A method of surmounting this difficulty would be to connect several chambers so as to feed an intermediate reservoir which would establish a mean pressure throughout. But this solution could not be carried out practically, for it is not profitable to store up heat in a receptacle where it cannot be kept

without serious loss.] Besides it would require between the chambers and the reservoir a whole system of valves, which it would be impossible to get to work properly.

M. Lemâle, in investigating the kind of nozzle most suitable for his continuous combustion turbine has been led to make some very interesting experiments. Having chosen a steam turbine nozzle fixed for the same fall of pressure as that expected, M. Lemâle established the expansion curve. To

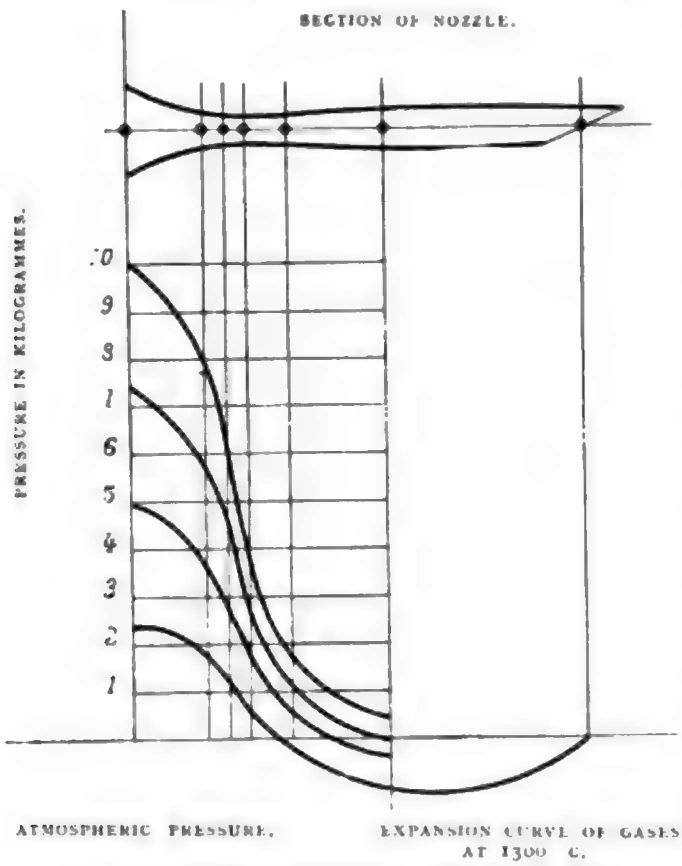


FIG. 1.—CURVES SHOWING RESULTS OF M. LEMALE'S EXPERIMENTS.

do this he made small openings two millimetres in diameter in the sides of the nozzle and to these openings he fitted in succession the tube of a manometer. The results of these experiments were expressed in curves (Fig. 1). It is seen that the steam nozzle, which is suitable for a pressure of 6 kilogrammes, is not at all suitable for a gas one; it is too long. The nozzle was then cut at the place where expansion was complete.

This proves experimentally what we have stated above, that in a turbine with discontinuous combustion, the nozzle is sometimes too short and sometimes too long, and that if it be assigned a fixed length the efficiency is very much reduced.

The construction of nozzles and the form which is most suitable for them are very interesting questions, but the scope of this article does not permit us to enter further into the subject here.

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## Turbines with Discontinuous Combustion.

The number of patents taken out for discontinuous combustion turbines is considerable. This form of gas turbine has attracted inventors more than the continuous combustion turbine on account of its more direct relation to explosion gas engines. But it should be noted that in recent years when internal combustion engines have made great progress, the number of patents for continuous combustion turbines has increased relatively to those for discontinuous combustion turbines.

Among the latter, we may distinguish 1st, apparatus in which the gaseous mixture is not compressed before each combustion.

2nd. Apparatus in which the gaseous mixture is compressed before each combustion.

In a certain number of patents for discontinuous combustion chambers, it is noted that the inventor has neglected to deal with the question of the compression of the air feed or of the gaseous mixture. In other patents, the inventors refer to independent compressors, but they have taken it for granted that such apparatus existed and have not considered its efficiency.

In this category figure the turbines of Griepe, Esnault-Pelterie, Armengaud, Sainte-Beuve, de Karavodine, and several others of less importance.

M. de Karavodine, particularly, has built an explosion gas turbine making 10,000 revolutions per minute which has been subjected to several tests.

We give in Fig. 2 an illustration of the combustion chamber of this turbine.

This chamber is of cast iron, and is provided with a water jacket, E, in its middle portion only; the upper portion not being cooled so as to allow of spontaneous ignition. At the lower end there are two openings, A and P,

for the admission of air and fuel. These openings are provided with throttle-valves by means of which the proportions of air and gas may be regulated. At D is a flap valve made of a thin steel plate which is kept in its place by the spring, R, and its lift is regulated by a set-screw. Ignition is effected at the start by the sparking plug, B. A discharge nozzle, T, is fixed in the upper portion of the chamber.

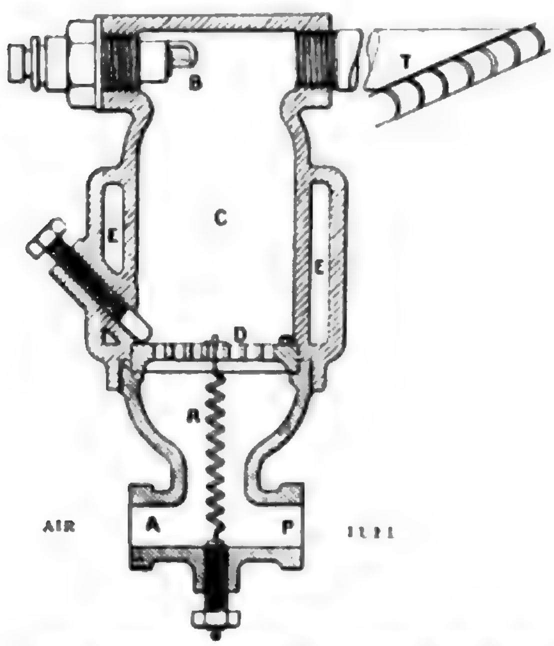


FIG. 2.—THE COMBUSTION CHAMBER OF THE GAS TURBINE OF DE KARAVODINE.

To start the machine, the tube A is closed, the gases are introduced and compressed at C, then ignited by means of a sparking plug. The first explosion followed by expansion produces a depression or partial vacuum, the effect of which is to refill the chamber with the gaseous mixture. The upper portion of the chamber is soon red-hot, and ignition can take place without the aid of the sparking plug. The detonations which follow have been compared to those of a Maxim gun. The turbine comprises four similar explosion chambers each provided with a long nozzle.

A turbine of this model has been tested; each chamber had a capacity of 230 cubic metres and was provided with a nozzle 3 metres long and 16 millimetres bore; the wheel was 150 millimetres (5·9 inches) in diameter.

The following were the results obtained:—

Number of revolutions per minute, 10,000.

Power determined by Prony brake, 1·6 horse power.

Air consumed per hour, 62·5 cubic metres.

Petrol consumed per hour, 6·5 litres or 4·7 kilogrammes.

If we estimate the power absorbed by friction at 0·5 horse-power, the actual power developed is raised to 2·1 horse-power, and the specific fuel consumption becomes 2·4 kilogrammes; that is, 2·4 kilogrammes of petrol per horse-power-hour. This means a fuel consumption one-third greater than that of the first Lenoir gas engine.

It is to be noted that in this class of turbine the combustion chambers are not closed at the moment of introduction of the gaseous mixture. It is understood that, in these conditions, initial compression is inadmissible and that the combustible mixture is subject to considerable losses.

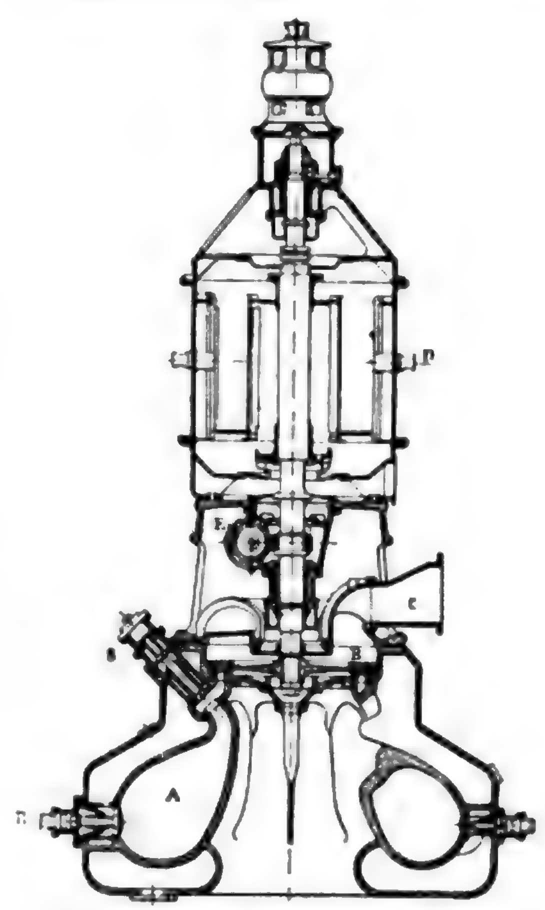


FIG. 3.—HOLZWARTH TURBINE CONSTRUCTED BY MESSRS. BROWN, BOVARI AND CO., OF MANNHEIM, SHOWING COMBUSTION CHAMBERS.

In the models of continuous combustion turbines, in which the gaseous mixture is compressed before each explosion, it is conceivable that the presence of the closing appliance in the combustion chamber itself, should limit the admissible maximum of temperature to such an extent that only a moderate efficiency can be obtained.

For this reason certain makers have brought forward devices for combustion chambers which are provided with valves, such as the Holzwarth turbine constructed by the firm of Messrs. Brown and Bovari, of Mannheim.

This turbine has been designed for an output of about 1,000 horse-power at 3,000 revolutions per minute, when it is fed with "lean" gas of 1,000 to 1,200 calories per cubic metre (112 to 134 British thermal units per cubic foot.) It consists of one or several explosion chambers A (Fig. 3), into which there are delivered separately through the valves R and P, both air and gas at a low pressure (an average of 1·5 kilogrammes per square centimetre) by means of a special pump which utilises the waste heat of the exhaust gases of the turbine.

When the chamber A is full of the explosive mixture ignition takes place, and the explosion produces an increase of pressure (7 to 8 kilogrammes per square centimetre) which raises an outlet valve S for the burnt gases of the explosion chamber. This valve is provided with an oil relay which retards its subsequent closing, and it gives the gases access to the expansion nozzles of a turbine B. This turbine is similar in construction to a high pressure steam turbine wheel, and the gases from it escape by the exhaust pipe C, in which a low pressure is maintained. At D there is a dynamo which is fitted on the turbine shaft. At E there is a horizontal shaft driven by screw-gearing and controlling the main governor, an emergency governor for preventing ignition, a tacheometer, the lubricating gear and the ignition mechanism.

This gas turbine works in the following way: When the explosive mixture is ignited the high pressure gases contained in the chamber A open the valve E and escape through the nozzle to act on the movable and fixed vanes of the turbine B. while at the same time the pressure in the chamber A gradually diminishes. Then when this pressure has become practically equal to that of the atmosphere, the inlet valve R is opened and the pump introduces into the combustion chamber A a certain volume of air which both cools it and clears out the burnt gases through the turbine wheel. This scavenging of the combustion chamber and the cooling of the turbine wheel are made possible by the oil relay of the nozzle-valve S interposed between the chamber and turbine wheel, whereby its closure is retarded. Then the inlet valve P delivers a new charge of gas and the successive operations of the cycle recur in the same order.

This gas-turbine has still a low thermal efficiency, since the figures given by its inventor seem to indicate that this efficiency does not exceed 11.2 per cent. of the total heat disengaged by the combustion, whereas certain modern alternating gas engines have an efficiency of 35 per cent.

The intermittence of the explosions in chamber A and the progressive expansion of the heated gases in it lower considerably the useful mean pressure at the entrance to the turbine wheel for a determinate maximum pressure in this chamber. The low initial pressure in the explosion chamber has not the same inconvenience here as it has in the case of an alternating gas engine, because in this gas turbine there is nothing to hinder lowering the final expansion pressure to the level of the initial pressure.

We shall not describe the different models of turbines with continuous combustion and previous compression, such as those of Messrs. Rüsch, Puycuyol, Fasbender, Floran de Villepigne, Breuils, and so many others, in which there is a rotor furnished with vanes, forming an explosion chamber, limited by a fixed casing. In these apparati the influence of friction must be considerable and their mechanical efficiency low.

To sum up, turbines with discontinuous combustion, for the reasons indicated, do not appear to be capable of affording a satisfactory solution of the problem of the production of motive power except perhaps in the case of low powers with valveless turbines and when the degree of efficiency is of little consequence.

AIR COMPRESSORS.

Before studying the turbines which make use of a compressed gas mixture, we shall say a few words about air compressors.

In a certain number of designs for gas turbines, the method of compression to be adopted is not mentioned, the inventors suppose that a compressed air apparatus or a compressed gas mixture is furnished, and in this way they avoid one of the greatest difficulties to be overcome.

In other designs, on the contrary, the compression of the gas mixture or of the air destined either to form this mixture or to clear out the burnt gases while producing a cooling effect, has been seriously considered. We shall divide the compressors which have been described into three classes:—

1. Piston compressors.
2. Rotary compressors.
3. Funnel compressors.

1. *Piston Compressors.*—The appliances studied are generally quite simple. They consist of simple pumps both aspirating and compressing; their construction presents nothing of special interest.

2. *Rotary Compressors.*—It is well known that compressors with alternating movement are quite suitable when it is required to produce high pressure with low yield of gas, but when large yields are demanded their obstruction increases rapidly. One method of limiting this obstruction would be to increase the speed of the pistons, but in this case a considerable amount of energy is wasted on account of the alternating movement and the vibrations produced.

For gas turbines, therefore, it has been proposed to employ multicellular turbo-compressors which are admirably fitted for the velocities involved in these machines. The compressor and turbine may then be fitted to the same shaft. M. Lemâle has shown in the following way that there is a striking correspondence between the velocities of the two apparati. It is known that, for the same elevation of pressure, if different yields are desired, it is always possible to get the same degree of efficiency by employing fans of different dimensions but of the same model, on condition that the angular velocity is made to vary as the square root of the yield. Consequently, for fans of the same type acting at the same pressure and working with the same efficiency the number of revolutions per minute is a known function of the yield.

This function is represented by the curve 1 (Fig. 4) in the special case of a wheel of a multicellular blower arranged for a compression of 1 kilogramme. In calculating, for each amount of yield, the power to be given to the corresponding shaft, the curve 2 may be constructed giving the value of this power as a function of the number of revolutions per minute. The correspondence between the powers and velocities which is clearly demonstrated by the latter curve, shows that it is easy to arrange turbo-ventilating groups with the desired powers and angular velocities without departing from the normal conditions of turbine installation.

The possibility of combining in this way advantages of the same kind, lightness, slight obstruction, ease of management, &c., has led to the invention of turbo-compressor groups whose efficiency is comparable to that of compressors with alternating movement.

The turbo-compressor consists essentially of a wheel revolving inside a casing. This wheel discharges at its circumference the air that has been drawn in through an opening in the nave. This air, which has thus acquired a certain velocity, enters a fixed air channel or delivery space called a diffuser of gradually increasing section. There the kinetic energy of the air is converted into pressure. If to this first element a second is adapted through which air is passed that has

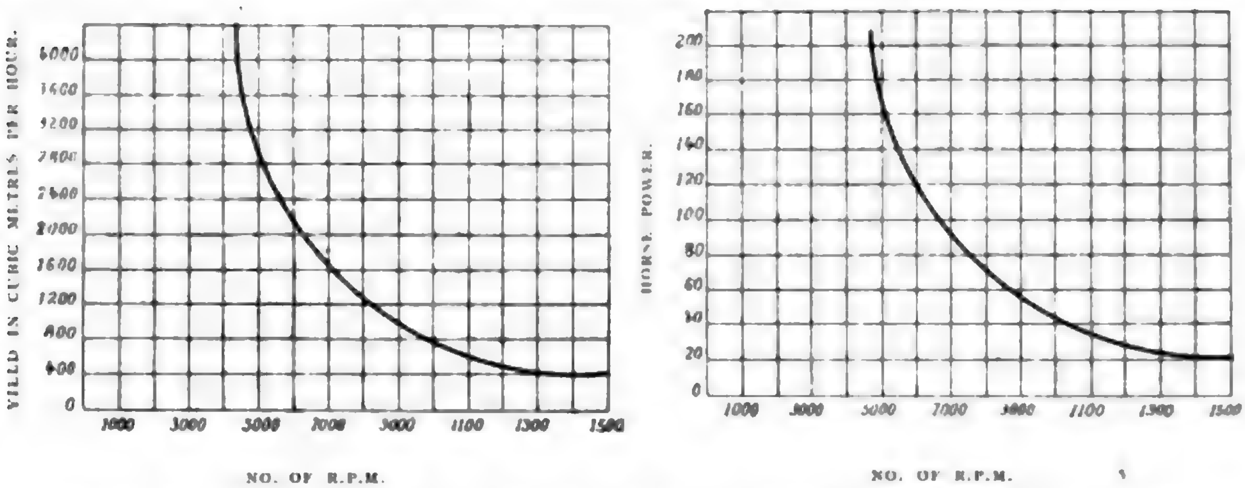


FIG. 4.—CURVES OBTAINED FROM A MULTICELLULAR BLOWER ARRANGED FOR A COMPRESSION OF 1 KILGR. THE CORRESPONDENCE BETWEEN THE POWER AND VELOCITIES IS SEEN IN RIGHT-HAND CURVE.

undergone the first degree of compression, its pressure is raised still further. If several elements are thus connected in series it is evident that the pressures after leaving each of the impelling wheels increase in geometrical progression; the elevation of pressure produced by each wheel being proportional to the specific gravity of the air, that is, to its pressure, the temperature being supposed to be constant.

Because of this arrangement in series, it is possible, without reaching very high peripheral velocities which would be incompatible with the requirements of construction, to obtain, with this class of apparatus compressions of several kilogrammes, and at the same time a considerable yield of air.

This, however, is only true if the compression takes place at constant temperature. In reality, the temperature of the gas is raised in consequence of the compression, and this rise of temperature takes place more rapidly if the compression is adiabatic. In consequence of this elevation of temperature the specific weight does not increase proportionally to the pressure,

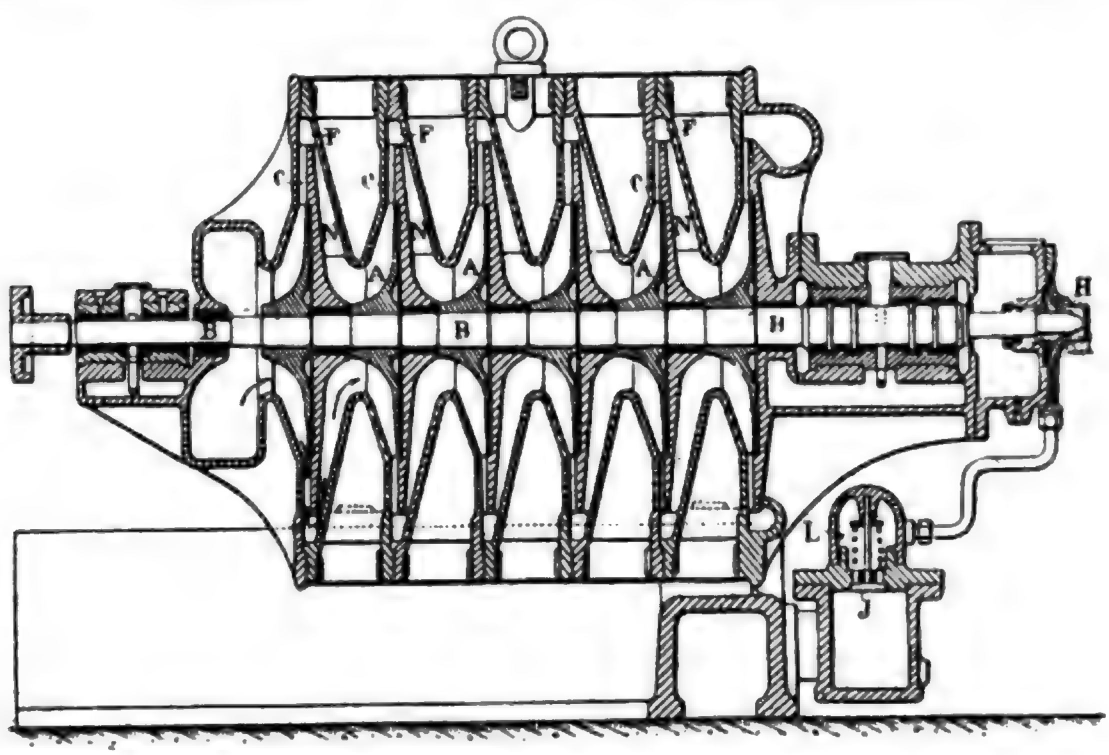


FIG. 5.—THE LEMALE MULTIPLE TURBINE COMPRESSOR.

and therefore the final pressures obtained will be sensibly lower than those indicated by theory. Hence the air must be cooled, either during compression or between the successive stages, in such a way as to bring it back to its original temperature, and so increase its density.

The multiple turbine compressor of M. Lemâle (Fig. 5) consists essentially of several steel wheels, A, which are fitted on a common shaft, B. The air enters the apparatus by a volute chamber, and is discharged by the revolving wheel into diffusers the section of which increases with the distance from the centre. The air of the diffuser having converted its kinetic energy into potential energy enters the directing air channels, F. The helical form of these channels is designed to reduce to a minimum the air impacts and eddies which absorb energy and diminish efficiency. Brought by the channels, N, to the centre, the air goes through the second wheel, and then through the others in the same way.

In order to simplify the construction, all the wheels are mounted in the same direction. The axial thrusts which they experience (on account of differences in the pressure applied to each of the faces) accumulate, and the resultant is a total thrust which it is necessary to balance. For this purpose a centrifugal oil pump is mounted on the end of the shaft in the opposite direction to the wheels of the turbine blower. It is placed there so that its own axial thrust may compensate that of the compressor. The oil is discharged to a valve, the tension of whose spring it is sufficient to change in order to modify the magnitude of the thrust.

After numerous tests, M. Lemâle has shown that the efficiency of this apparatus reached 72 per cent. efficiency here meaning the ratio of the theoretical amount of work of actual compression to the amount of work communicated to the shaft.

M. Rateau has patented a device for cooling the air in the course of its compression. This device consists of a cold water refrigerator in which cooling is effected by mixture, that is, water is injected into the air, which passes through the apparatus in the form of a jet, which is as finely divided as possible. The refrigerators are interpolated between the different elements of the compressor.

The firm of Messrs. Brown, Bovari and Co. has constructed compressors of this type, which deliver in one hour 65 cubic metres of air at a pressure of 4·8 atmospheres. Apparatus of this kind allowed in 1907 an efficiency of 75 per cent. to be attained.

3. *Funnel Compressors.*—As we are limited, for mechanical reasons, in our choice of the diametric magnitude of the vaned wheels and in the angular or peripheral velocities to be given to them, we are compelled to connect in a series a large number of discs in order to obtain a sufficient elevation of pressure. The Armengaud-Lemâle "Société des turbo-moteurs" has purposed, for applications in which the efficiency of the turbo-motor group is secondary, or in which reduced obstruction is of most importance, to make use of funnels, or, in other words, injectors which are fed by a portion of the gases of combustion derived from the combustion chamber itself or from an auxiliary chamber.

According to M. Rateau the funnels may reach an efficiency of 60 per cent. for an upward and downward pressure ratio equal to five, on condition that the mass of the fluid carried in should be nearly equal to that of the carrying fluid. It is quite certain that this condition cannot be fulfilled in actual practice, but it is nevertheless possible to assign to the funnel such dimensions that the yield of air carried in can be increased in proportion to the yield of carrying gas, with the object of absorbing, for the feeding of the funnel, only a portion of the total yield of gases, equal to or a little greater than the half.

At present, rotary multicellular compressors take from the total energy of the turbine a portion which corresponds to nearly one-half of the amount developed. It should be noted, however, that in this particular case the work necessary for the driving of the

compressor is derived from the action of the turbine, and must consequently be reckoned with the efficiency of the turbine itself.

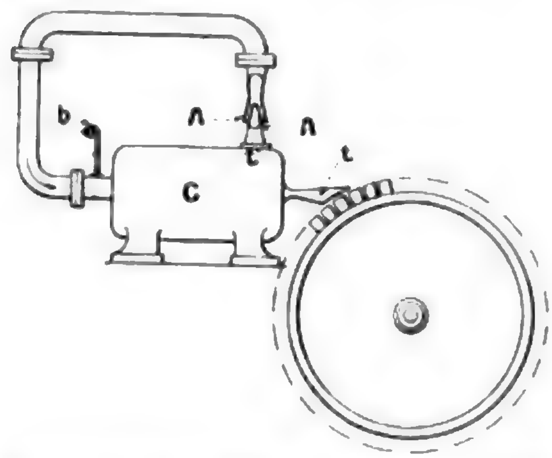


FIG. 6. SHEWING FUNNEL FITTED TO THE COMBUSTION CHAMBER OF AN ARMENGAUD-LEMALE TURBINE.

The system of compression by funnel would appear then to have this advantage, other things being equal (the potential energy of the gases under pressure being directly utilised for the suction and discharge of air) of not interposing the efficiency of the turbine in the compression of the charged air. Nevertheless, given that the ratio of the yield of air carried in, to the yield of burnt gas is necessarily greater than unity, the efficiency of the funnel may fall to 40 per cent. or even lower. It is for this reason that the employment of such a funnel is only suitable in those cases into which the question of economy does not enter, or in which the slight obstruction of the machine is an indispensable condition. Fig. 6 represents one of these funnels fitted to the combustion chamber, C, of the Armengaud-Lemâle turbine. The air is drawn in at A, the combustible gas is introduced through b, t' represents the secondary nozzle through which a portion of the burnt gases escapes, t is the working nozzle.

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*Continuous Combustion Turbines.*—A certain number of inventors have studied continuous combustion chambers without providing any appliance for cooling or recovery of gas, the burnt gases being allowed to escape into the atmosphere after acting on the blades. Let us mention in this connection the apparatus of MM. Anne, d'Arblet and Meineke, but the majority of inventors have studied turbines which make use of mixed cycles.

If, in an internal combustion engine, a satisfactory efficiency is desired, the work of compression must be diminished as much as possible, for it should always be borne in mind that this work is derived from the engine itself. This operation of compression should therefore be exercised upon the least possible volume of gas. Now, unless excessive compression is resorted to, exceeding, for example, a ratio of 80, it is not possible to introduce more than 450 calories per kilogramme of gas, while certain combustible mixtures could easily supply 550 to 600 calories. It is necessary, therefore, to dilute these mixtures and consequently to increase by 20 to 30 per cent. the mass of gas to be compressed. This objection is still greater if less is compressed.

These considerations lead us to enquire if it is not possible to employ rich combustible mixtures without dilution, but limiting by certain devices either the temperature of combustion or the final temperature of expansion.

In order to lower the temperature of combustion several processes present themselves :

1st. Cooling the combustion chamber externally by means of water circulation and the discharge of the water.

2nd. Cooling the combustion chamber externally by means of water circulation, and the utilisation of the vapour produced—

(a) in a special turbine, (b) in the turbine itself.

1st. By injecting it into the combustion chamber.

2nd. By directing it on to the blades by means of special nozzles.

3rd. By injecting it into the nozzle for the expansion of the gases.

It should be noted at once that the first method of cooling is disadvantageous from the cooling point of view since the thermal units carried off from the gases through the wall of the combustion chamber do not participate any further in the operation. Very

few inventors have provided for the utilisation of the thermal units carried off in this way from the burnt gases.

In order to lower the temperature of the gases after expansion injection of water, vapour or air may be resorted to.

In the first case, the heat of vaporisation of the water involves a loss of thermal units, since it is derived from the heat of the gases.

In the second case there is no such loss, but the velocity of discharge of the steam must be equal at least to that of the gases, otherwise it would involve difficulties with the discharge of gas. M. Sekutovics has shown that when steam is injected among the gases after their expansion, the useful effect is slightly less than that obtained by injecting this steam before expansion. It is assumed, of course, that this steam is produced by means of the heat lost by the engine itself.

Compressed air may also be injected into hot gases, but in that case an amount of energy would have to be expended in a blower equal to the kinetic energy required, because a velocity must be imparted to this air at least equal to that of the hot gases. It is more advantageous to compress all the air employed and to discharge the whole of it into the combustion chamber than to compress a part of it only at the pressure of combustion, and then to pass the remainder into a blower supplying the chambers with the mixture.

We shall examine these cooling processes in turn.

1st. *Combustion chambers cooled externally by means of a water circulation, the water being afterwards discharged.*

Few inventors have neglected to utilise the thermal units carried off in this way from the combustion chambers. On the other hand, those who have sought to feed their turbines by means of the gas from successive explosions have generally neglected this part of the question.

2nd. *Combustion chambers cooled externally by means of a water circulation, the steam formed being afterwards utilised.*

(a) Utilisation of the steam in a special turbine.

Inventors have not been attracted by this method of utilisation; they naturally prefer to make use of the same turbine in order to utilise the steam formed.

(b) Utilisation of the steam in the same turbine. The steam is injected into the combustion chamber.

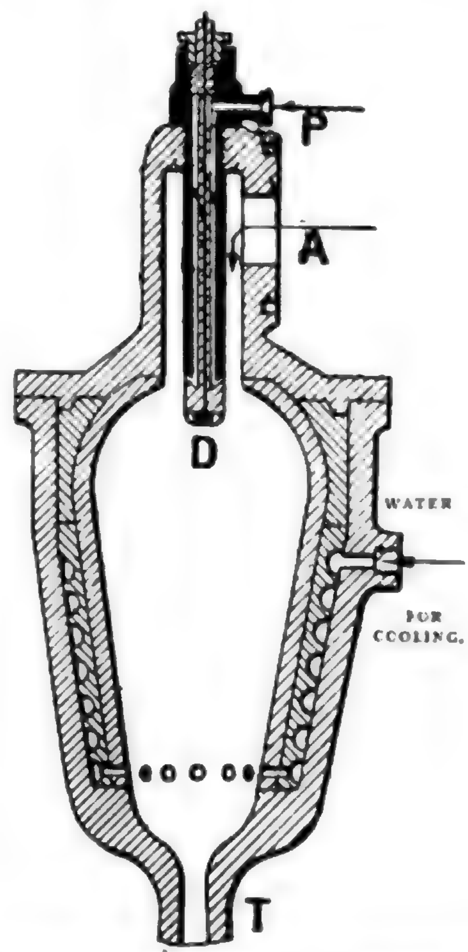


FIG. 7.—COMBUSTION CHAMBER OF ARMENGAUD-LEMALE TURBINE LINED WITH CARBORUNDUM AND INTERLINED WITH POWDERED ASBESTOS AND CALCINED MAGNESIA.

There is a device of this kind in the Armengaud-Lemâle turbine, of which the following is a brief description: The combustion chamber represented in Fig. 7 is lined internally with carborundum; the interval between this lining and the steel is filled with a mixture of powdered asbestos and calcined magnesia. A is the opening through which the compressed air is introduced.

Ignition takes place at D by means of a platinum wire which has been made incandescent by the current from an accumulator. A steel sconce prevents the platinum wire from being extinguished by the current of air.

When the internal lining has been brought to a red heat, no other ignition device is required. This apparatus is so well known and has been described so often that we shall not deal with it further here.

(c) Conveying the steam in special nozzles.

The device patented by M. Lemâle, in 1906, is represented in Fig. 8. Cold water is introduced into the water jacket surrounding the combustion chamber near the end of the nozzle, and passes in this jacket in an opposite direction to that of the current of gas, in this way producing a cooling effect in a methodical way. The steam accumulates in the reservoir V before being discharged on the blades by a special nozzle T, which opens at a short distance from the nozzle $T_1$.

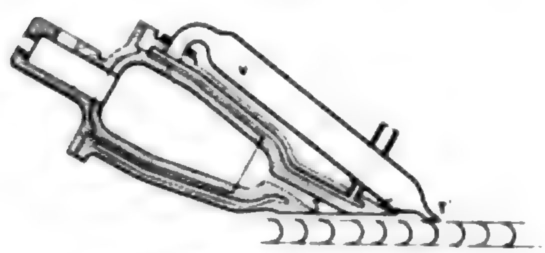

FIG. 8.—LEMALE'S COOLING DEVICE.

M. Lemâle has further solved the problem of cooling and at the same time utilised the thermal units carried off by the burnt gases, by converting the narrow portion of the combustion chamber into what is actually a tubular boiler. (Patent of 1907.) Tubes communicate with two parts of the boiler. The steam formed accumulates in the reservoir and is discharged by the nozzle on the blades at a certain distance from the nozzle, which discharges the products of combustion.

*Injection of gases into the expansion nozzles.*

There are no turbines in which steam is injected under these conditions; but that of the Kerr Turbine Company employs compressed air with this object.

*Lowering the temperature of expansion.*—The different methods which may be employed to lower the temperature of expansion of burnt gases have already been described. They need not be repeated here, but a short description may be given of a turbine in which one of these methods is employed.

M. Windhausen cools the gaseous products of combustion as they enter the nozzle by means of a jet of water moving in the same direction as the current of gas. The steam produced is thus mixed with the gas and produces its effect on the turbine wheels. The nozzle itself is cooled by an external water jacket which completely surrounds it. The water of this jacket has already cooled the cylinder which surrounds the vaned wheels and the directing discs which it contains.

In other variations of his turbine M. Windhausen has completed the cooling by means of a water circulation round the combustion chamber.

M. Windhausen has further dealt with the cooling of the whole apparatus in a more complete way, and has provided for the permanent discharge, in the form of jets, of a large quantity of water in the combustion chamber for the purpose not only of cooling the latter but also to clear out the gases and avoid impurities.

Finally, the appliances of Holzwarth, Klötzer, de Bonnechose, Parsons and Teyssedou are modelled on those which have just been described.

* * *

The possibility has also been considered of substituting for atmospheric air in the gaseous mixture, either oxygen or air rich in oxygen.

M. Claude has succeeded in producing this gas at a sufficiently low price to be used in blast furnaces. The idea of using it in an internal combustion engine is therefore not an absurd one. In this order of ideas, all the difficulties connected with the compression of inflammable and combustible gases would be done away with and it would be possible to make the compression and expansion ratios equal to 500, for this would be necessary in order to send into the turbine only gases which were sufficiently cooled.

Such compression ratios would be realised by maintaining, for example, a pressure of 25 kilogrammes per square

centimetre in the combustion chamber of the turbine and causing the latter to open into a water-cooled condenser in which a pressure of 1·20 kilogramme per square centimetre could be maintained.

But if it were desired to maintain a very high temperature, such as 2,000° C. in the combustion chamber, in order to obtain a high efficiency, the fluids should discharge into the turbine with a velocity of about 2,400 metres. In order to turn this velocity to account, the turbine would have to acquire a tangential speed of 800 metres, and this would not be possible with the present kinds of steel.

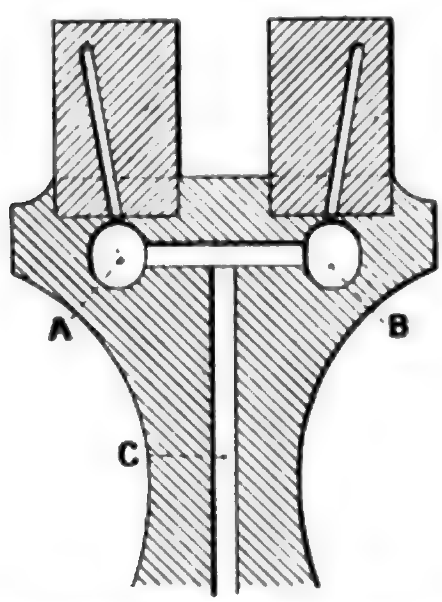


FIG. 9.—SECTION OF TURBINE BLADE WITH INTERIOR WATER CIRCULATION.

The turbine having its tangential speed reduced to 460 metres per second, it would not be convenient to carry the temperature in the combustion chamber above 750°C. by injecting water into it. In these conditions it would still be economical and could be of service if the price of oxygen per ton did not exceed one-fourth of the price per ton of combustible employed.

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The scope of this article does not allow us to go into the question of turbine blades, we shall confine ourselves to a few remarks on the different devices which have been put forward to secure the cooling of these parts. The cooling fluid is generally compelled to enter the cycle of the turbine, and consequently this question is intimately associated with those which have just been treated.

From the standpoint of efficiency, there is an advantage in directing the gases upon the turbine blades at the highest possible temperature, but on the other hand it is well known that the resistance of metals diminishes rapidly with the elevation of their temperature. Now the metals which enter into the construction of turbine blades are subjected to considerable strains as the result, particularly, of the centrifugal force.

Metallurgy furnishes at present tung-

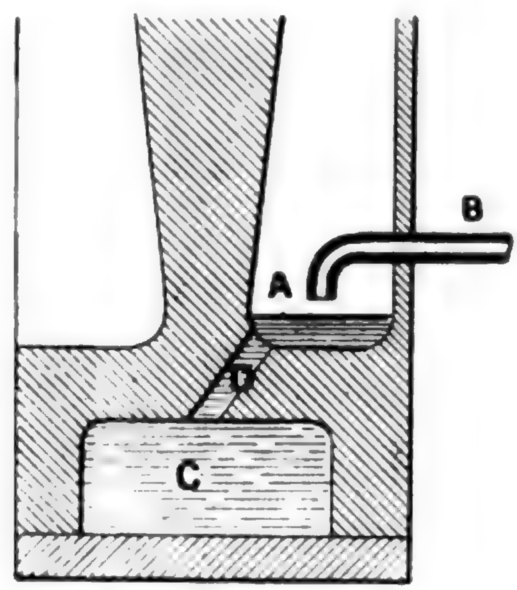


FIG. 10.—KERKAU'S BLADE COOLING SYSTEM.

sten and vanadium steels, termed high-speed tool steels, which possess a high degree of resistance even at a temperature of 600 C., and which can be worked for a long time at a red heat without deterioration. M. Lemâle has mentioned a nickel steel with which he had constructed a turbine blade, and which was subjected for months to a temperature of 450° C. without exhibiting the least fatigue

There are likewise tool steels manufactured by crucible or in the electric furnace, which have resistances of 100 kilogrammes per square millimetre with an elongation of 5 to 10 per cent. even at 600° C.

These temperatures, however, form the superior limits which must not be

exceeded while we are waiting for new metallurgical processes.

This is the method, then, by which inventors have solved the problem.

In the turbine of M. Fullagar, the blades are hollow, and are cut out of steel tubes which have been hammered into the form of crescents. A current of cold air or steam is discharged into the interior.

M. Weiss employs a similar process, but he causes the cooling gases to participate in the work of the turbine.

MM. Armengaud and Lemâle have arranged a water circulation in the interior of the turbine blades themselves. Fig. 9 shows a section of a turbine blade treated in this way. A and B are circular pipes to which the water has access and from which it is carried away by radiating pipes such as C. Each of the blades is perforated and the small channels are in communication with the circular channels A and B. Cold water being denser than hot water, the centrifugal force has a greater effect upon it; this force, which drives the cold water towards the circumference is therefore greater than that which the hot water has to overcome in order to flow from the circumference towards the centre.

Usually the cooling of the disc is effected by means of steam or water and the currents travel from the centre to the circumference, then they separate in the circular tube near the rim. This method of circulation assumes that the velocity of the disc is not too great, so that this velocity offers no hindrance to the circulation of the cooling fluid in the circular tube in an opposite direction to that of rotation.

M. Kerkau has offered the objection to these latter devices that the water can only remain in the wheel for a period which is very short in proportion to the magnitude of the centrifugal force which acts upon it, and that, consequently, a considerable yield of water would be needed in order to obtain a satisfactory degree of cooling. Since this large quantity of water must acquire an enormous tangential velocity with a considerable loss of energy as a result, M. Kerkau proposes to lead the water for cooling into a groove A of the wheel by means of a tube B (Fig. 10.) Under the influence of centrifugal force this water penetrates through the tube D into the hollow pocket C in the interior of the blade. The water is soon evaporated and the steam escapes by the same pipe B; it is replaced by the cold water which the centrifugal force drives towards the circumference. In this way the water introduced into the wheel is completely converted into steam.

We cannot deal at greater length with these devices whose interest, moreover, is only secondary in comparison with the much more complicated problems which are presented by the study of the gas turbine.

# MODERN DEVELOPMENTS IN FIRE PREVENTIVE DESIGN AND CONSTRUCTION

By Harold G. Holt. A R I.B.A.

PROGRESS in matters of fire protection has been very rapid during recent years, more particularly in the direction of structural improvements. It has come to be more generally realised that the structural aspect of fire protection is of greater radical importance than the extinctive or palliative aspect. Fire insurance offices place less reliance on the chance of a poorly constructed building, amply equipped with sprinklers, alarms, and fire fighting devices, than was formerly the case. Experience has repeatedly demonstrated that such buildings stand a poor chance in a general conflagration, and in the case of individual fire outbreak. It has been shown that well constructed buildings have acted as efficient fire stops in even the most overwhelming conflagration, in which fire departments were practically powerless. At the same time there is less talk of "fire-proof" construction, and more is heard of "fire-resisting" construction, thus showing the trend of modern technical opinion.

Largely owing to the educative work of such bodies as the British Fire Prevention Committee, the basic fact that the fire-resistance of a particular building depends very greatly on individual details of construction and arrangement, is becoming much more widely recognised, as is also the fact that to claim in general terms that a building is "fire-proof," means very little and is quite misleading. The expression "semi-fireproof," as applied to timber constructions protected in a measure by more or less fire-resisting materials, is also calculated to mislead. Either buildings are *fire-proof* or they are not, and, as it has been repeatedly shown that no material used in the ordinary construction of buildings is absolutely proof against the influence of high temperature continuous for any considerable period likely to be experienced in a great conflagration, it would seem more reasonable that the expression *fire-resisting*, as advocated by the British Fire Prevention Committee and the International Fire Congress, should be more generally used.

Again, it is easily shown that the resistance to fire possessed by various building materials varies considerably, even with regard to materials closely allied in nature. Thus various types of concrete vary greatly in efficiency as fire-resisters, not only depending on the nature of the aggregate, but upon the quality of cement, mixing and grading of the aggregate, wetness of the mixture, etc.

Thus it becomes necessary that in order to gain a clear notion of the degree of fire resistance possessed by materials, proprietary and non-proprietary methods of construction and building details, as shown by actual test in large specimens, various classes of protection should be recognised. Such have been set up by the British Fire Preventive Committee and have received world-wide recognition on the same basis. They are as follows:—

TEMPORARY PROTECTION.—Implying resistance to fire for at least forty-five minutes.

PARTIAL PROTECTION.—Resistance to fire for at least ninety minutes.

FULL PROTECTION.—Resistance to

FIG. 1.—INTERIOR OF A "FIRE-PROOF" COTTON MILL AFTER FIRE. NOTE THE BUCKLED WROUGHT IRON JOISTS AND GENERAL STEEL SHAFTING COLLAPSE.

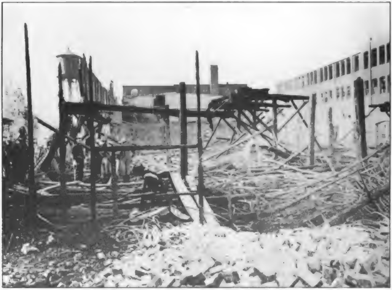

FIG. 2.—UNPROTECTED AMERICAN CAR FACTORY AFTER FIRE.

fire for at least one hundred and fifty minutes.

Many materials used in building construction are not capable of withstanding fire to any extent without being so seriously injured as to imperil the structure of which they form part. Timber of small scantlings has, of course, always been recognised as inflammable and unsafe, though the degree to which some of the hard woods will withstand fairly high temperatures for a short time was not formerly recognised, and the claims of chemically treated non-flammable timber are not sufficiently recognised, in the writer's opinion, for such uses as temporary buildings, railway carriages, etc. Formerly all materials known to be not inflammable were considered fire-proof, and thus wrought iron, cast iron and later, steel, were employed as structural agents, entirely unprotected from the ravages of fire. The results of such construction are well illustrated by the photograph, in Fig. 1, after a severe fire which gutted the premises. Unprotected cast iron columns, unprotected cast iron girders, and wrought iron joists, carried heavy brick arches, which crashed through floors below. The results of fire in a timber structure, unprotected, are also shown in Fig. 2, a photograph of an American car factory. This has since been replaced by a reinfo ced concrete structure, built on the Kahn system in forty days. Fig. 3 shows result of fire in a north-country factory, of unprotected construction.

It is, of course, a commonly recognised fact that all steel structural or weight carrying members should be protected against fire. The advent of the American skyscraper has wielded a vast influence over matters of fire protection on account of the huge risks involved, and although we in this

*Photo.*] FIG. 3.—UNPROTECTED ENGLISH MANUFACTORY AFTER FIRE. [*"Daily Mail."*

country will probably never be faced with exactly similar problems, there has been a reflex action in our modern methods of building, due very largely to the experience gained in skyscraper steel f ame construction. A dominant factor in all modern systems of fire-resisting is this very matter of the protection of steel members, which are being more and more used in our buildings. It is over this very matter that the much vexed question, "Tile or Concrete?" is asked continually. What are the claims of the two methods of protection, terra-cotta tile block as opposed to concrete protection? The hollow tile manufacturer states, accurately enough, that a material which has passed through severe fire, will withstand high temperatures far more successfully than one which has not been through a similar ordeal. Hollow tile blocks are made from clay, kiln burned at a temperature of from 2,000 to 2,500 degrees Fahr. They are made in three grades, "dense," "semi-porous" and "porous." The former is the strongest from a constructional standpoint, but is very poor in fire-resistance, and many failures and collapses in fires of American buildings have been due to the use of the "dense" quality of terra-cotta. "Porous" tile is, on the other hand, a good fire-resister *per se* and, moreover, extremely light, a cubic foot of tile weighing about 40 lbs. This lightness is a factor very greatly in favour of porous tile as a protection for steel in a tall building; by its use the ultimate weight of the building is much reduced, and consequently the cost of steel construction and foundation work is lessened. Tile floors and partitions are quickly erected and rapidly dry and afford facilities for the "rush construction" so dear to the hearts of the American builders. The infilling between the steel frame forming the exterior spandril walls is frequently constructed in hollow tile. This is clearly shown in Fig. 4, which is a view of the Marlborough-Blenheim Hotel, Atlantic city, in course of construction, the completed building being illustrated by Fig. 5. This hotel is 560 ft. long, 125 ft. wide and nine floors high. There are, then, advantages in the use of tile construction of the right class, but the evidence against "dense" terra-cotta is overwhelming. At the San Francisco conflagration and at the Baltimore fire, "dense" terra-cotta was proved an absolute failure. The "Horn Building" in the Pittsburg fire of a few years ago was completely gutted in two hours, though protected in the best manner then in vogue, by "dense" terra-cotta tile.

You cannot burn a piece of "dense" or semi-porous tile; if heated and then subjected to water, it will not become disintegrated. What is the reason, then, for such failures? It is not far to seek. Whatever the grade of tile, it is used primarily as a covering to steel girders or columns, and also largely in the form of flat or segmental arches, and, be it remembered, in the shape of a hollow block, the faces of which are united at intervals by thin webs of the material. In spite of care in manufacture, the blocks are often cracked across corners or in the webs and breakages occur in trans-shipment, points of weakness being thus developed. In case of fire, particularly in girder or column casing which is naturally exposed to fierce heat, the unequal expansion of the outer face of the blocks as compared with the inner face against the steel, is frequently sufficient to overcome the resistance of the connecting webs, which break away and cause the collapse of the blocks, in part. The immediate expansion of the exposed steel is sufficient in many cases to loosen the remaining blocks or crack them severely. In the case of floor arches the girder is first protected by special shaped tiles which form a skew-back for the arch blocks. The protection of the steel girder soffite, a most important matter in fire protection, is often inadequately performed by tiles specially shaped, chiefly where the flanges are wide.

L shaped tiles are often used in which the width of the lower portion is excessive, hair cracks being developed across the junction with the upright, and the unequal expansion produced by excessive temperatures in the exposed lower portion are certain to lead to

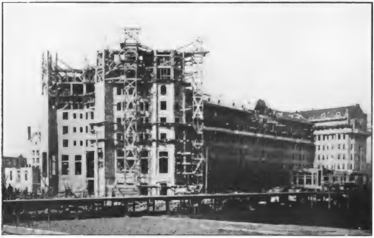

FIG. 4.—MARLBOROUGH BLENHEIM HOTEL, ATLANTIC CITY, U.S.A., IN COURSE OF CONSTRUCTION BY THE TRUSSED CONCRETE STEEL CO., LTD.

failure in the case of fire and consequent exposure of steelwork. Sometimes flat soffite tiles are used in which metal wires are embedded and turned over the lower flange for support; inverted L pieces are then used to complete the flange protection. The use of such metal attachments is another cause of failure, and has been strongly deprecated by insurance underwriters. On large span floor arches the effect of great heat has sometimes been to produce such expansion of the blocks as to cause crushing of some of the tile shells and consequent collapse of portions of floor panels. Fig. 6 shows

FIG. 5.—BUILDING SHOWN IN FIG. 4 COMPLETED.

various forms of girder protection and floor construction in terra-cotta hollow tile.

With regard to cement concrete as a protection for steel, certain advantages may be urged. Foremost of these is the almost equal expansion of concrete with steel, as against the very unequal expansion of the latter with terra-cotta tile. Again, there is the natural affinity or bond of cement concrete with steel, and the preservation by cement of steel against corrosion is a matter which cannot be overlooked. These three factors have been perhaps the chief ones which have lead to the far reaching application of concrete and steel in the form we know as reinforced concrete. Without them the resistance of concrete to compression and the resistance of steel to tension and shear become isolated facts. With these properties concrete and steel may be safely and economically combined to form a monolithic, homogeneous structure.

Added to these properties that of the thermal non-conductivity of concrete as proved by many experiments and tests, the insulation of steel against heat by a concrete casing becomes a potent determining factor in the question of steel protection and fire-resisting construction in general. As previously remarked, however, the degree of fire resistance possessed by various types of concrete varies considerably. The second report of the Royal Institute of British Architects on reinforced concrete (1911) points out that concrete composed with a limestone aggregate crumbles in exposure to fierce fires, gravel and sandstone concretes suffer less, and concrete made with well burned furnace slag or coke breeze is but superficially injured by fire. Concrete of broken-brick aggregate is more affected than cinder concrete and less than stone or gravel concrete. This is what one would expect, remembering that burned materials do, in general, withstand fire better than unburned materials. Granite, although of volcanic origin, does not withstand fire well, it is cracked and splintered, and eventually crumples to an amorphous powder; pumice or lava concrete on the other hand is a splendid fire resisting material.

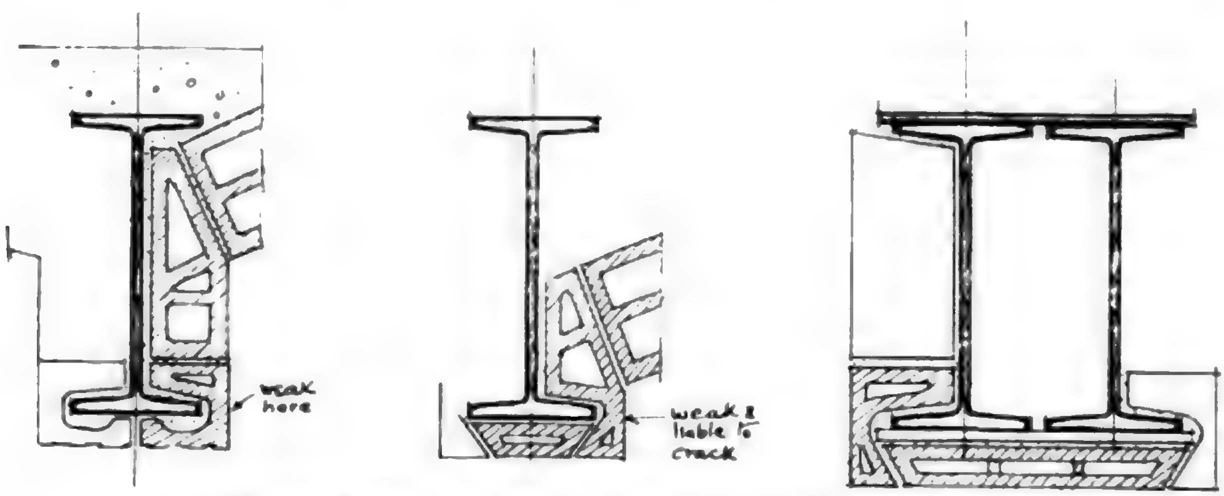

FIG. 6.—STEEL GIRDER PROTECTED BY TERRA-COTTA TILE. AMERICAN SYSTEM.

A case in point, with regard to the difference made by aggregates to the fire resistance of concrete, is that of a floor, tested by the British Fire Prevention Committee in 1905, constructed with broad flange steel beams and Thames ballast concrete. This floor failed very badly in the test, but a similarly constructed floor, save that furnace clinkers formed the concrete aggregate, proved highly successful in an exactly similar test and was classified as affording " full protection."

The size of piece to which the aggregate is broken also affects the fire resistance, for the pitting of exposed concrete faces in fire when subjected to jet from high pressure hose, corres-

ponds roughly with the size of individual pieces; small pieces are also better for complete infilling around joists or reinforcement. It is worthy of note that a "wet, rich mixture" is better than a "dry" one for purposes of fire resistance because concrete, to become hot enough to be disintegrated must have previously parted with its water of crystallisation, and this is a very slow process. It is rendered slower in the case of a wet mixture and it is presumed that a fine coating of dehydrated mortar is formed on the exposed face of the concrete, in high temperature, which protects the interior of the concrete from further dehydration for a considerable length of time.

Against the use of concrete as a steel protection and fire-resisting medium it is argued by tile manufacturers that (1) many failures of reinforced concrete have taken place, due to the effect of fire in some cases.

(2). It is shown that cinder or breeze concrete has often proved dangerous and sometimes actually inflammable in fires, and has a bad effect on steel embedded in it in a considerable number of cases.

(3). It is also demonstrated that most concretes are considerably heavier than hollow tile and additional cost of steel is thereby rendered necessary; it is not dried so quickly as tile and takes longer to be deposited *in situ* than tiles are fixed.

These arguments are true to a certain extent, but are only part of the truth.

Reinforced concrete has largely passed the experimental stage and most of the early failures have been explained. Such failures are due to inefficient design, bad quality of cement, improper grading and use of unsuitable aggregates, lack of proper supervision, poor workmanship, carelessness and striking of centreing before concrete has been thoroughly set. A formidable list, but one which has been thoroughly grasped and taken to heart by concrete designers and constructors, and in no way detracting from the intrinsic value of properly designed and constructed reinforced work. Most failures in case of fire—and they are very few compared with the failures of dense terra-cotta—have been due to *inadequate protection of steel*. Many designers appeared to consider, until quite recently, that ½ in. of concrete to outside reinforcement was ample protection against weather or fire. It has been shown by experimentists, large tests, and as the experience of actual fires in buildings that a *minimum protection of two inches* of suitable concrete is necessary in such positions as the soffites of steel girders and 1½ inches in the case of small steel joists, rods, &c. Something depends, of course, on the size of reinforcement; thus a 1 in. round rod offers but little exposed surface as compared with a 3 in. by 1½ in. by 4 lbs. rolled steel joist; the type of aggregate and its size will also affect the minimum dimension, but the above is a safe general rule.

With regard to (2) breeze concrete, it is most necessary to insist on all burned material having been thoroughly burned. Pan-breeze is notorious for being partly burned coke and partly imperfectly burned coal slack; it also contains sulphur, which has a deleterious effect on Portland cement and may lead to steel corrosion. Breeze concrete is very porous and this quality renders it of greater fire resistance, in a similar manner to porous tiles; should the tamping of such concrete be imperfect and voids be left such porosity is likely to lead to quick corrosion of the steel. Breeze concrete is not used in reinforced concrete work proper since it has not the resistance to compression offered by other types of concrete of inferior fire resistance. It is much used, however, in the form of slabs for partition and ceiling construction and a good field is offered as an additional protection to less fire-resisting concretes which possess better structural qualities. Breeze and slag for concrete should be thoroughly clean, washed and free from sulphur.

(3). That concrete is in the main heavier than semi-porous or porous tiles is undeniable. For this reason reinforced concrete is, in the main,

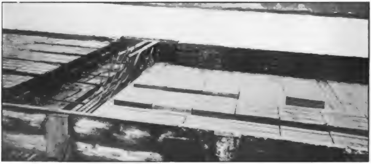

FIG. 7.—COMBINATION OF REINFORCED CONCRETE AND TERRA-COTTA TILE.

unsuitable for the construction of extremely high buildings, since the size of piers necessary to carry the loads would entail excessive waste and loss of valuable floor space and light.

Tile construction, solely, has some advantages not possessed by reinforced concrete and *vice versa*. The majority of technical opinion in England is undoubtedly greatly in favour of concrete as a protection for steel, and in America perhaps the balance is somewhat in favour of tile, but even there, opinion is veering round. Frame buildings of reinforced concrete are now common, but they are usually of moderate height.

A further development of the controversy referred to has been a compromise between the tile and concrete interests which has led to the combination of both forms of con-

FIG. 8.—HOLLOW TUBE CONCRETE SYSTEM.

The photo is of the Albert Foundry, Belfast, in course of construction by the Armoured Tubular Flooring Co. Ltd., of London.

struction. Reinforced concrete beams, carrying porous tile floor bays, are often met with. Such floors have been largely adopted by the National Fire-proofing Company, the leading hollow tile manufacturers of the United States, in conjunction with various systems of reinforced concrete. Considerable saving in centreing is effected, long spans are erected with less depth of floor, and the thrust of tile arches, which often necessitated the use of unprotected tie rods—always a source of danger—eliminated. Not only rod and bar reinforcement is used, but various types of vertical mesh reinforcement are adopted with the concrete and form a binding for the hollow tiles. Fig. 7 shows Kahn reinforced concrete joist and hollow tile floor in an American building.

Suspended ceilings are frequently adopted to afford a level ceiling throughout and to give additional fire protection besides providing an efficient sound and heat insulator. The building for the Fire Insurance Underwriters' laboratory, Chicago, stated by insurance experts to be the best type of fire-resisting construction in the United States, is constructed with steel girders protected by specially thick terra-cotta blocks and the floors are on the "Johnson" system, a combination of hollow tile and mesh reinforced concrete protected in addition by a ceiling of terra-cotta porous tile, laid herring bone, immediately below. Expanded metal lathing and concrete is frequently employed as a suspended ceiling and special attachments and hangers to steel girders are provided.

A later development is that of the hollow concrete block or tube floor. Such floors consist usually of joists of concrete, reinforced by special bars or rods carrying hollow blocks of light breeze or pumice concrete. (See Fig. 8). In some cases the blocks themselves are reinforced on their lower edge and are laid side by side.

The advantages of such construction are that the whole flooring area is cast in moulds previously to being brought to the job, and is ready for immediate erection, and quickly dries. Wooden forms or centres are avoided except to the concrete haunch on the steel girders upon which the ends of the joists or tubes lie. A thin layer of wet concrete is deposited on the upper

FIG. 9.—STEEL BOOK SHELVES AND FITTINGS IN AMSTERDAM BANK. RONEO FIREPROOF CONSTRUCTION

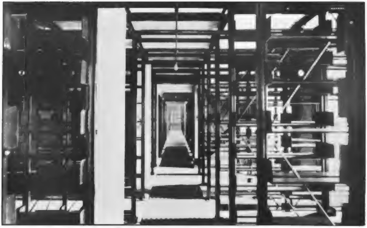

FIG. 10.—STEEL LIBRARY FITTINGS BY RONEO, LTD., OF LONDON.

surface of the whole floor which may be finished with one of the patent jointless floors, now much in vogue.

The ultimate fire-resistance of buildings depends very greatly upon the design and general arrangement.

Such points as staircase and elevator shafts, service lifts, dumb waiters, ventilating shafts, light wells and areas demand considerable knowledge of fire-fighting conditions if the best possible results are to be achieved. External openings, such as windows, doors, etc., need special protection against the external fire hazard, in many instances. Fire-resisting shutters afford the best protection against excessively severe exposures and should act automatically in case of fire outbreak. In less exposed situations some form of fire-resisting glazing, such as wired glass or electro glass in metal frames, should be provided.

Internally the avoidance of floor openings, or their efficient cut off. must be one of the main considerations, otherwise rapid spread of fire from floor to floor is a certainty, and in case of outbreak the fire department is offered little chance of successful dealing with it if numerous flame and smoke ducts are provided. The efficient splitting up of a building into numerous fire-resisting compartments is a most successful form of construction for store, warehouse, hotel, and office buildings where it can be arranged, in which case all doors or other openings into the compartments or units must be fire-resisting also.

The limitation of cubical capacity in any compartment of a building is now recognised by all fire protection experts as a matter of the utmost importance. The lack of such precautions as opening protection, limitation of contents and efficient cut off at floors was directly responsible for the loss of the Equitable Building, New York, on January 12th, 1912. In this case a building covering a block of 48,000 superficial feet ten stories high at parts was unprovided with any proper sub-division to limit the capacity of each department, and the floors were pierced by a number of lift, stair and light shafts in a most hazardous manner. The fire occurred in the early hours of the morning, and thus the fire department was practically unhindered, save by severe weather. The lack of efficient exits for the 1,500 daily occupants of the building was another amazing oversight, and that appalling loss of life would have

occurred had the outbreak taken place several hours later is certain. Six persons lost their lives in the fire. In the very able report on this fire, made by Mr. F. J. T. Stewart, Superintendent of the Bureau of Surveys of the New York Board of Fire Underwriters, it is recommended that the height of " fire-proof " buildings should be limited by the adequacy of their fire protection, whether by internal structural fire stops, and opening protection, smoke-proof stair towers and hydrant equipment for the use of firemen, or automatic sprinklers, &c. The report has been published by the British Fire Prevention Committee, and forms particularly instructive reading with regard to the American point of view.

Narrow buildings, accessible at either end only, form bad fire risks. It is almost imperative that such buildings be lighted by a central court, area, or light shaft, and the staircase and lifts are usually placed in the vicinity. A favourable opportunity for the quick spread of fire to all floors is thus immediately presented and unless very adequate cut offs are provided and fire-resisting glazing and shutters installed *and used* at vertical and horizontal openings, disaster will take place sooner or later. Planning and arrangement with regard to section of buildings is a much more important matter than many people suppose, and new developments are continually taking place with regard to special protection of the risks that may arise in various types of building.

A logical outcome of the development of general arrangement and detailed fire preventive construction is the elimination of combustible contents in the shape of floor boarding, dadoes, skirtings, mouldings, door frames and partitions, desks, shelving and furniture.

That large fire losses do take place in buildings fully equipped against destruction by fire is self-evident. The percentage of such losses is often out of proportion to the cost of the structure itself, and in such cases is due to costly material and decoration being spoiled by fire or by the destruction of valuable works of art, jewellery, pictures or perhaps securities. Particularly in large public buildings in which such valuables may be stored, libraries, museums, art galleries, &c., is the elimination of all burnable materials desirable. Such fittings are not essential, and may be replaced by steel fittings of good design, clean, sanitary and fire-resisting to a point (see Figs. 9 and 10). Lockers, desks, files, bank and library fittings may be arranged compactly, economically and on fire-preventive lines by the installation of such fittings, and further development in the direction of steel office furniture, wall linings, etc., may be expected in the near future.

# CAB SIGNALS AND TRAIN STOPS

**By Wm. H. Dammond, C.E., F.P.W.I.**

In view of recent accidents this article should prove of special interest. Even since it was written several more have unfortunately occurred, which, the author contends, would have been prevented by a cab signalling system, particularly in the case of the Aisgill disaster. It is certainly time that the whole question should be thoroughly investigated, and while holding no brief for any particular system, we trust that this may be done.—EDITOR.

RECENT railway history furnishes numerous instances of accidents of a kind that may aptly be termed "fixed signal wrecks." These accidents, of which Vauxhall, Ditton, Bromford Bridge and Marylebone are English examples, result from causes which, practically speaking, cannot be prevented by fixed signals, but cannot occur with modern cab signalling. The cost of installing, also the combined costs of maintaining and operating the systems in which these wrecks are *inevitable*, are greater than the same costs in a system in which such accidents are *impossible*. So far, then, as "fixed signal wrecks" are concerned, there are at present two alternative courses open to the railways: they may pay heavily and get wrecks, or pay less and avoid them.

The gain indicated in this contrast is not merely apparent, it is a real advance. Although cab systems *per se* if universally adopted would still leave railways unprotected against other classes of wrecks, yet the cab system would not increase the number of these other wrecks nor offer any impediment to their extinction. To cite a specific instance, cab signalling would certainly not have prevented the notable collision at Hawes Junction, nor the very recent and less disastrous one at Dalmuir. Track circuiting offers at present the only sure preventive of accidents of this class. But track circuiting can be used quite as readily with modern cab signalling as with fixed signalling.

One exceedingly serious mistake that formerly was met with everywhere is now becoming obsolete. This is the false notion that cab systems are a mere bad weather expedient. The argument in favour of cab systems in American and Canadian snows and British fogs is plainly unanswerable. But, until quite recently, railway officials generally have overlooked the important fact that, although bad weather does *increase* the need for cab signalling, such weather does not *cause* that need. Bad weather did not cause the accident at Marylebone Station nor the one at Wavertree Junction (December 11th, 1912); yet both of these collisions would have been prevented by modern cab signals. Entirely apart from weather conditions, then, exclusive fixed signalling is wrong.

Installed at some places as a train-stop, and at others as a cab signal, cab systems have been in regular service in France for more than twenty years, in England and the United States for over five years. Besides all this, a vast number of full size, long time, bad weather and high speed tests of cab systems has been made in the past ten years in the latter two countries, and in Germany and Canada. From data furnished by this extensive and varied experience, it is now easily possible to *prove and correct* the faults of present practice. Railways using fixed signals exclusively are perfectly right in refusing at present to instal any of the cab systems *now in regular service*; but it is entirely wrong for any of these railways to fail to profit by the *marked improvements* made in cab systems in recent years.

The "Piccadilly Tube" collision has been erroneously pointed to as justifying the proposition that the existence of a cab system on a railway would cause drivers to be less attentive than they otherwise would be of fixed signals. This proposition is a dangerous fallacy, to which this "Tube" collision lends no support. The driver was as "inattentive" of fixed signals at Vauxhall, and again at Lombardstown, *where there was no cab system*, as he was on the Piccadilly Tube, where a

cab system was in service. The driver's failing to get, or his misinterpreting a *properly indicating* fixed signal, is wholly or partly the cause of numerous wrecks on lines where no cab system has ever been installed. Such wrecks are, *per contra*, almost absolutely unknown on lines where safe handling of traffic is exceedingly difficult, but where cab systems have been in use for several years. Even the primitive and exceedingly faulty cab system used as a train-stop on the Piccadilly Tube has furnished a higher margin of safe operation there than could possibly be attained by fixed signals alone. A modern cab system, fulfilling those correct signal engineering requirements which the "Tube" cab system violates, would unquestionably have prevented the "Tube wreck."

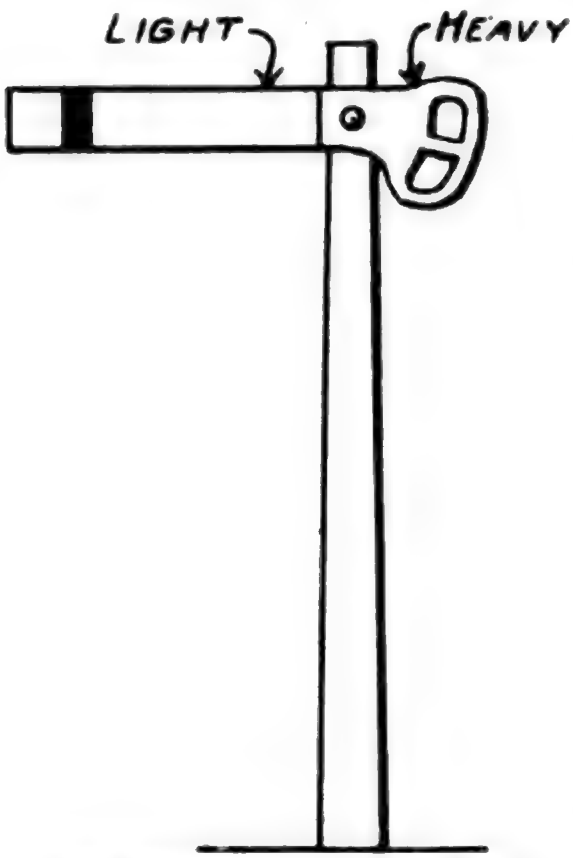

FIG. 1.—SIGNAL HAVING WEIGHTS OF PARTS PROPERLY DISTRIBUTED.

Fig. 1 illustrates an application of a correct signalling principle that is strictly obeyed by exclusive fixed systems, but that is violated by manv cab systems, including train-stops in use on the London underground railways. In this figure the weight of the spectacle casting is sufficiently greater than that of the semaphore, to insure that the latter shall go to the danger (horizontal) position by *gravity*. Contrast this with Fig. 2, which illustrates a numerous class of faulty cab systems.

Fig. 2 pre-supposes that each train carries a "trip-cock," the lower end of the handle of which lies about an inch or more above the track rails; and this trip-cock, if thrown, will effect the application of the brakes and thus stop the train. The duty of the apparatus shown in Fig. 2, then, is to cause the stop arm to rest in the position shown broken-lined (so as not to throw the trip-cock on a passing train) when the fixed signal is at clear; and to cause the arm to be up in the full lined position (ready to throw a trip-cock) when the fixed signal is at danger. The stop arm is depressed pneumatically. When the track ahead becomes occupied, air is permitted to escape from the air cylinder; and the spring is depended upon to return the stop arm to the raised position, so as to protect an oncoming train. If the spring should become clogged with dirt, ballast or snow; or the connecting rod should become bent or broken, the next train would be imperilled.

The better train-stops and cab signals now obtainable, not only eliminate this spring and rod arrangement, but also

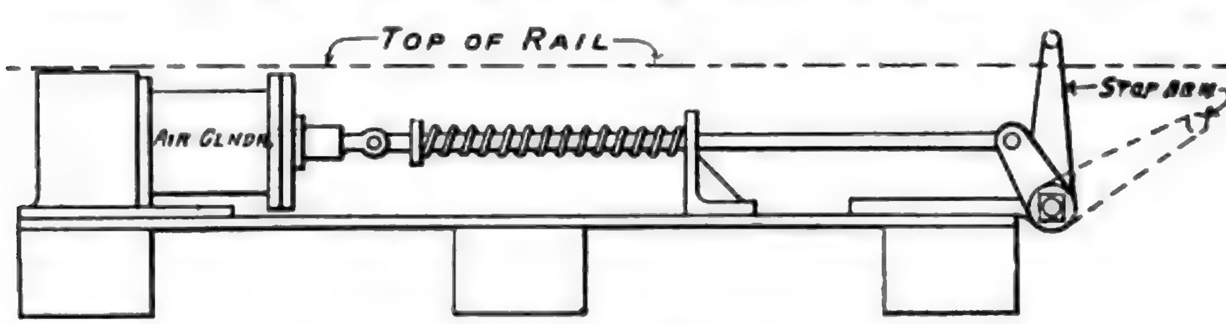

FIG. 2.—TRACK-CONTAINED STOP-ARM FOR CONTROLLING TRAIN-CARRIED TRIP-COCKS.

do away with the necessity of providing compressed air all along the line—a prohibitively expensive item in any but an urban railway. Instead of the exposed moving parts of Fig. 2, which are open to the danger of freezing in the clear position, the modern cab systems provide a *fixed* ramp, which cannot fail to perform its part in protecting the train, no matter what the condition of the weather. But *earlier* fixed ramp systems yielded a superiority more apparent than real, as we shall presently see.

In addition to the system shown in Fig. 2, there are many others of the trip-cock type, including those in use on the New York Subway, the Boston Elevated Railroad, and the San Francisco, Oakland and San Jose Railway. The Pere Marquette Railroad tried one of these inferior systems at Detroit in 1910, and the Pennsylvania Railroad at Philadelphia in 1911. The various systems of this class differ widely from each other, but all of them are decidedly inferior to any one of several fixed ramp systems, including the one illustrated by Fig. 6.

The change on the track, from a stop arm to a fixed ramp, involved concomitant changes on the train. A simple trip-cock and a fixed ramp would constitute an impossible combination; since they would co-operate to stop the train at *every* ramp, no matter what the condition of the track ahead. In fixed ramp systems, therefore, the simple trip-cock is replaced, on the train, by an electrically operated stop-valve, and the circuit to this valve is controlled by a ramp-engaging member also carried by the train. At any given ramp, then, the *invariable* moving of the ramp-engaging member may be accompanied by electrical action or not, according to track conditions ahead; and the electrical action may quite easily be made to oppose the mechanical action in the effect produced on the stop-valve. In this class of systems, the mechanical lifting of a ramp-engaging member causes the train-stop to act; hence, the combined and mutually opposing lifting and electrical effects at a ramp must hold the train-stop out of action. The best fixed ramp systems to-day are those in which (*a*) when the train is between the ramps, the cab signals are held "off" (train-stop out of action) by current generated *on* the locomotive; (*b*) the train-stop is held out of action (cab signals held "off") at proper ramps by current generated *off* the train; (*c*) electricity is *not employed* to send the audible or visual cab signals "on" (or to apply the train-stop).

There is no practical difficulty in making a simple trip-cock handle light, so as to avoid serious trouble of breaking, by impact with a stop arm, at rather high train speed. The foregoing advantages of the fixed ramp systems were discounted, at first, by the practical fact that a ramp-engaging member must be *virtually* heavy. In other words, this member, even if actually light must, nevertheless, press heavily on ramps; since heavy pressure is practically indispensable to good electrical contact between a train-carried member and a dirty, rusty, or icy ramp. The *striking point* of a heavy member receives more punishment than the *same* point of a light member provided the *striking speed* of the member is the same in the two cases. But a sharp distinction must here be drawn between the striking speed and the train speed.

Fig. 3 shows in simplified form a cab system type which has enjoyed considerable favour. While certainly *evading* the impact trouble just mentioned, the system in Fig. 3 does not practically cure that trouble. This system requires the engine to be insulated from the tender and, at each signalling point, a small length of track rail to be insulated from the adjacent portions. One terminal of the coil of the signal magnet is connected to one pole of the locomotive battery, the remaining coil terminal being earthed on the engine, and the remaining battery pole earthed on the tender. As appears from Fig. 3, when the train is anywhere between two signalling points, the signal is held at clear, in consequence of the circuit from the locomotive battery being completed through the track rails. When the train arrives at a signalling point, after the *last* engine wheel enters the insulated

rail, and until the *first* tender wheel enters the same rail, this circuit is open at the insulated rail joint, and the signal, thus far will go by gravity to danger. But if the switch is closed the coil circuit instead of being broken is diverted so as to be completed through the track battery.

In Fig. 3, if the insulation in the locomotive coupling should break down while the signal is " off ", the circuit from locomotive battery to signal magnet would be completed through this coupling. The signal would, therefore, continue to indicate clear even when the engine and tender become separated by an insulated rail-joint, and the switch is open. Here, then, the cab signal would continue to indicate clear, even when the track ahead is dangerous. A like effect would result from the accidental earthing of the insulated rail section. Without mentioning further objections which probably suggest themselves, this kind of cab system perfectly eliminates impact trouble—only to introduce grave troubles that were absent before this cure (?) was applied.

Various types of " wireless " systems have been looked upon as affording means for obviating this impact trouble, but not a single " wireless " system worthy of adoption has yet appeared. The fact that many " wireless " systems actually require *much more wire* than equally good " non-wireless " systems weighs, of course, against the former. Some wireless systems employ current to give a danger signal (or to apply brakes), which is a direct violation of a fundamental principle of safe signalling (or train stopping). It is quite true that there are wireless systems which are perfectly free from this last defect; but the very fact that they are " wireless " imparts to them a dangerous quality from which the fixed ramp type is utterly free. In wireless systems the signal magnet, on a given train, may hold a signal at clear as a result of either induction or Hertzian waves (according to the particular system considered) from a primary circuit or a " wave wire " intended for another train. The corresponding danger of holding the train-stopping

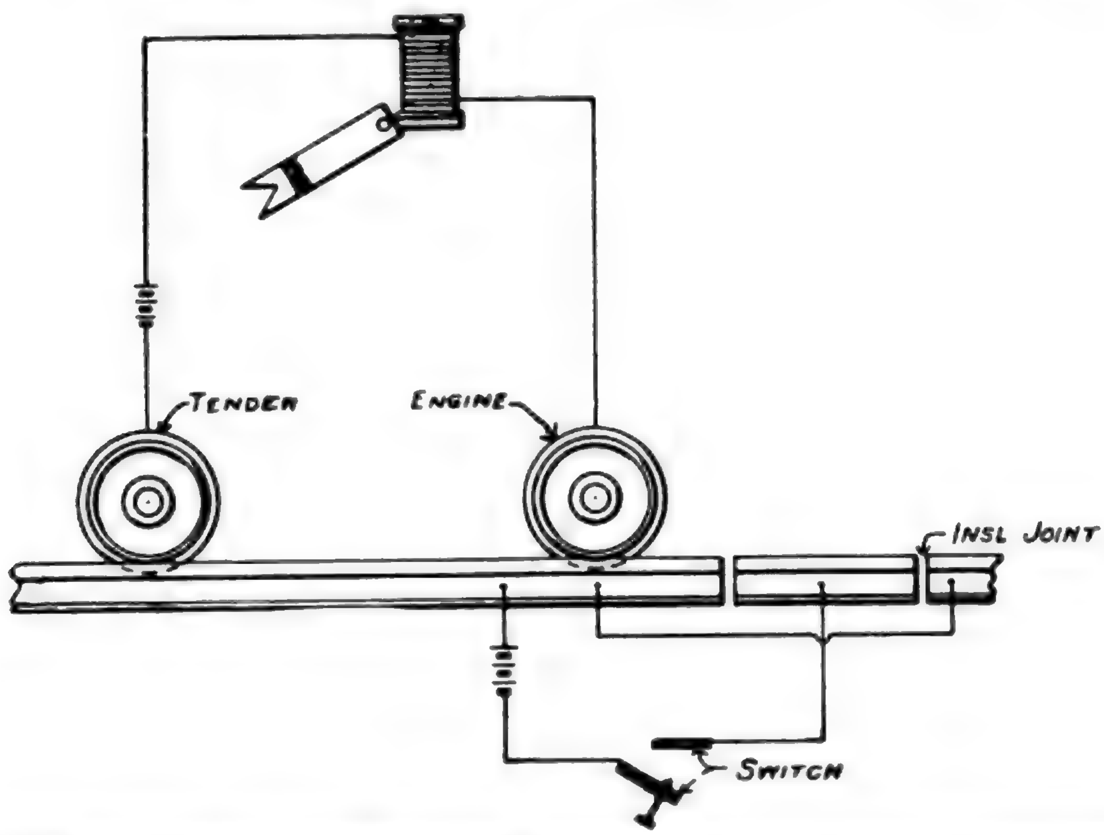


FIG. 3.—CAB SIGNAL EMPLOYING SHORT INSULATED TRACK RAIL SECTIONS AND INSULATED LOCOMOTIVE PARTS.

apparatus out of action is, of course, present in wireless systems employed as train-stops. The well known phenomena which present themselves here would produce a sufficiently dangerous tendency in simple track lay-outs. These phenomena would constitute a formidable menace in the exceedingly numerous lay-outs in which a primary circuit or a wave wire for one route ought to be "dead" at a given instant, but would have to cross, at very acute angles, the "live" primaries or the "live" wave wires of several other routes.

Eliminating, as utterly worthless, all systems, whether ramp or wireless, which employ electricity either to give a danger signal or to apply the train-stop, it could easily be proved that the sole advantage that a "wireless" system *per se* could give over a ramp system is to prevent impact. But breakage and rapid wearing are the only evil effects of ramp impact; and ramp type cab systems that have recently appeared reduce these evils to a purely negligible quantity.

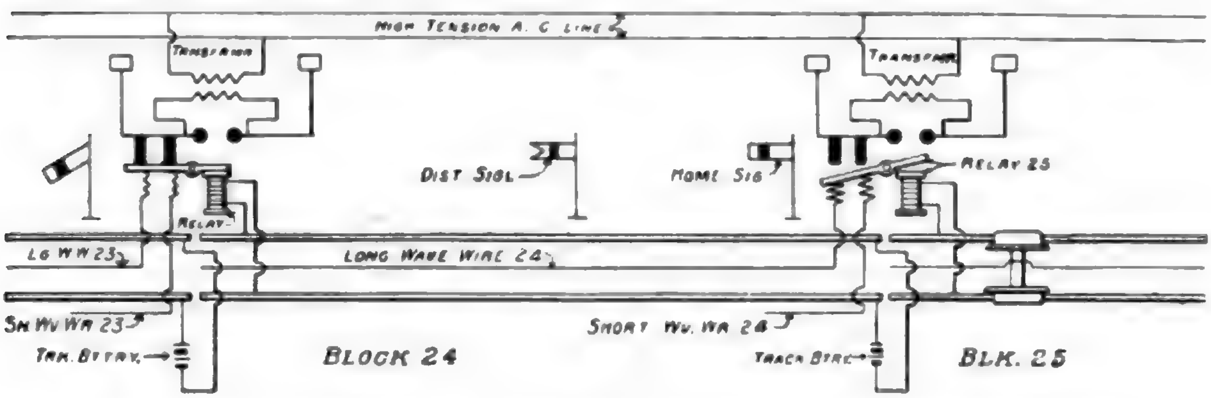


FIG. 4.—TRACK ARRANGEMENT OF A "WIRELESS" CAB SYSTEM OF THE HERTZIAN WAVE CLASS.

Fig. 4 illustrates a track arrangement for the Hertzian wave class of wireless cab systems. Apparatus of this class has been installed experimentally in both Canada and the United States. Fig. 4 shows one block complete, together with the forward portion of the preceding, and the rear portion of the following block. For convenience of reference, these blocks are numbered 23, 24, and 25, the complete block being 24. The track rails of any block are separated from those of the adjacent blocks by insulated joints, the electrical discontinuity being represented in the drawing by the breaks in the track rails. It will be observed that in addition to the distinctive Hertzian wave apparatus, this system utilises the well-known track circuit commonly employed in automatic fixed signalling. Here, then, the track battery and the relay in any block are connected to the track rails of that block, the battery at the forward, and the relay at the rear end of the block. By this arrangement the track rails of any given block serve to carry current from the track battery normally to the relay. But the presence of a pair of ordinary metal train wheels in a block will shunt current away from the relay. In countries like England, where the wheel centre and rim are insulated from each other, in the case of passenger cars, it would be necessary to bond the two parts of the wheel. But this cannot be considered as a detriment to the wireless cab system, since such bonding is perfectly feasible, and is equally necessary for modern automatic fixed signalling.

In Fig. 4, it will be observed, a transformer, actuating an oscillator, is provided at each block junction, the transformer being fed from a pair of high tension wires running along the railway. Since block 24 is clear, current from the track battery will energise the relay of this block, but since block 25 is obstructed, track battery 25 (not shown) will not energise relay 25. Hence, relay 24 will be closed and relay 25 open, as drawn.

Wave wires 24 will thus be cut off (at relay 25) from contact with their oscillator, while the contact finger of relay 24 will connect wave wires 23 with their oscillator. While a train runs through block 23, the antennæ on the train will pick up Hertzian waves from live wave wires 23, and these waves will cause the cab signal to be held at clear and train-stop out of action; when the train enters block 24 the train-carried antennæ will pick up no waves (since wave wires 24 are dead), and the cab signal will go to danger and the train-stop be applied.

The wireless system shown in Fig. 4 cannot give distinctive home and distant cab signal (or stop) effects. Moreover, the cab signal will go to danger (or stop will be applied) as soon as the locomotive enters block 24, which is too soon. No railway ought to adopt a cab system which (under normal circumstances) requires that the driver must be permitted to disregard a danger cab signal. Of course, making the cab signal and stop magnets release slowly does not meet the case. On account of the wide variation of signal point intervals and the enormous variation of speed of any given train, the proper rate of magnet release for low train speed, or long signal intervals would produce an even worse result than that just noted; it would delay the danger signal (and stop action) for the high speed, or short interval.

Fig. 4 presupposes the idea of controlling the motions of trains by means of coherers on the locomotives! An even worse class of wireless cab signals and train-stops was recently tried in Germany. Even if a coherer circuit on the locomotive were entitled to serious consideration, it could at least be said that Fig. 4 makes a proper use of such an element; since, in this system, waves transmitted to the coherer produce the clear signal, or hold the brakes off. In the German system, however, the waves are transmitted to the coherer to give the danger signal, or to apply the brakes, and this is precisely what such waves should not be used for. The reported results of the tests (?) of this German cab system prove nothing. The promptness with which the train is stopped demonstrates the efficiency of the brake and not of the train-stop. This important distinction may be exemplified by reference to the recent Yeovil wreck. According to the Great Western driver's testimony, the brakes on the locomotive at Yeovil were quite capable of effecting the quick stopping that was so irrelevantly enlarged upon in accounts of the German trials, but these brakes did not prevent a serious wreck. A proper cab system (signal or stop) would certainly have prevented the Yeovil collision—not, however, by providing braking power, but by ensuring the application of the brakes at the proper time. In considering any proposed train-stop, the all important criterion is not the quickness with which the brakes stop the train, but the certainty with which the train stop applies the brakes.

Fig. 5 shows, simplified, a cab system which has been in regular service in France for many years. Here the danger whistle, in the cab, is controlled by a whistle magnet. One side of this magnet is earthed on the locomotive, the other side being connected to a wire contact brush suspended from a low point on the locomotive. At each cab signalling point on the track a contact bar is located, rising to sufficient height to be rubbed by the contact brush of any passing locomotive. In each signal box is a battery and a switch. One side of this battery is grounded on the track rail, while the other side is connected to the contact bar, the circuit from battery to bar being controlled by the switch.

When a train, carrying a mute whistle, encounters a contact bar, the switch for which is open, the whistle remains silent; but when the train encounters a bar, the switch for which has been closed by the signal-man, the circuit from the battery is for the moment completed through the coil of the whistle magnet. This magnet, then, momentarily attracts its armature, thus opening the whistle valve, the stem of which is fastened to the

armature. The armature is so controlled by springs that, once put in either extreme position, it will remain there until started, electrically or manually, to the other. Hence, the

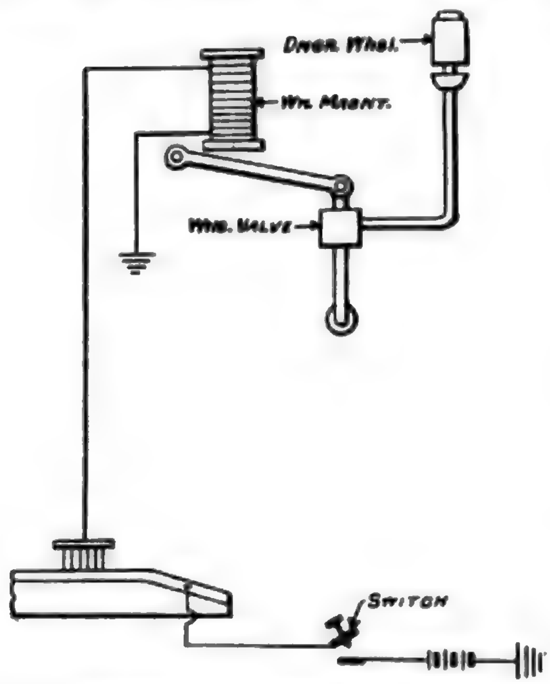


FIG. 5.—CONTACT BAR TYPE OF AUDIBLE CAB SIGNAL.

whistle will continue to blow, even after the locomotive leaves the contact bar, until the driver shuts the whistle valve.

The system illustrated in Fig. 5 is one which no railway could afford to adopt to-day. A single broken wire or broken connection, is sufficient to jeopardise a train. An exhausted battery or a single ground on a ramp or a brush, or on a wire connected to either would produce the same dangerous error.

Fig. 6 illustrates one of the fixed ramp cab systems which corrects the serious defects that are now known to be possessed by *all* of the cab signals in *regular service in England*. This system, as a visual and an audible cab signal, has been the subject of perfectly conclusive full size tests. No such failure as a single ground, open circuit, or exhausted battery, also no concurrence of any number of failures of one or more of these three classes can prevent the giving and the continuance of the danger signal, visual or audible. Since a train-stop valve in no wise differs fundamentally from a danger whistle valve, this system, when used as a stop, possesses the merits just noted for it as a cab signal. This system is here shown, for simplicity, as a visual and an audible home cab signal only, but it can be used for both distant and home cab signals. Moreover, it can be used for either permissive or absolute working (American practice), and for giving starting and advance starting information (British practice).

In Fig. 6 the ramp-engaging member is an insulated wheel, which is knocked into rotation by impinging on a ramp. The circuit through this wheel is restricted to the lower part. Hence, the signals must go to danger instantly if the wheel should become so broken as to prevent the proper working of the system. Contact of wires with wheel is, of course, effected by "brushes" which are rubbed by the wheel as the latter rotates. The circuit breaker is carried by the axle box of the insulated wheel, but is here drawn out of its proper place, in order to show the wiring clearly. When the wheel is raised by a ramp the circuit breaker is opened and the signals go to danger by gravity assisted, in the case of the audible signal, by steam pressure. But this is prevented if the ramp relay (or ramp switch) is closed, for then the whistle and visual signal magnets will be thrown in circuit with the ramp battery during the time the circuit breaker is open.

For a long time, inventors of ramp systems made the mistake of employing a shoe or lever as the ramp-engaging member. This apparently resulted from two errors, one of which was the opinion that a sliding member afforded better electrical contact with ramps than could be secured by a rolling member. The other error consisted in overlooking the fact that a very great reduction of impact is attainable by the extremely simple expedient of a properly proportioned turning member. Even in those cases where wheels were used, apparently to reduce ramp friction, these wheels were so designed as to leave the destructive tendency on the *striking point* practically un-

diminished as compared with the punishment experienced by the *same* point on a shoe.

A ramp-engaging wheel which rotates with a peripheral speed equal, at any instant, to the train speed will entirely eliminate all *trouble* from breaking on ramps, provided the radius of the wheel is large as compared with the rise of the wheel on the ramp. those which such a wheel obviates. For obvious practical reasons, this wheel would have to be smaller than any train wheel, preferably much smaller, and since it rotates *continuously* (while the train is in motion) the wear saved at the ramps would partly re-appear at the axle of the ramp-wheel.

A ramp-wheel which is "rotatable,"

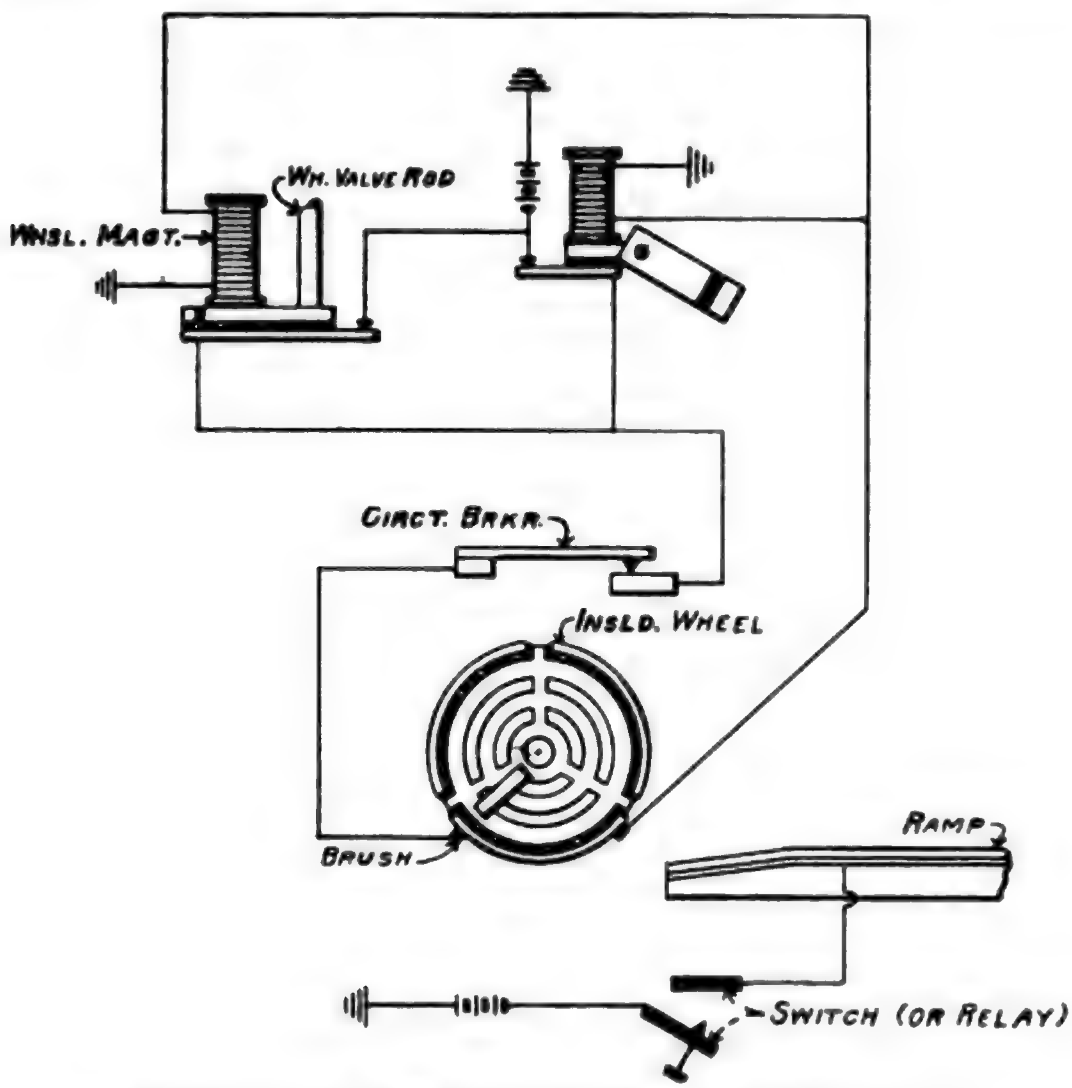


FIG. 6.—FIXED RAMP CAB SYSTEM OF THE "ROTATABLE" RAMP—WHEEL CLASS.

Such a wheel, on the train, and a ramp, at signalling points only, constitute an eminently practical pair for a cab system. A wheel of this kind offers a *real* cure for the impact difficulties encountered in the earlier development of fixed ramp cab systems; for, while this wheel introduces some troubles not experienced with the shoe or lever, the added troubles are exceedingly less than that is, which does not turn until knocked into rotation by a ramp, has further improved this class of cab systems. In this connection it must be remembered that the ramp wheel is an electrical contactor as well as a mechanical member, and the "brushes" which rub against the wheel for electrical purposes slightly oppose rotation. Because this wheel rotates only intermittently, it reduces

to a negligible quantity the axle-bearing trouble of the former wheel. Theoretically, this rotatable wheel stands between the shoe and the continuously rotating wheel in the matter of primary importance, viz., ramp impact. Practically, however, the rotatable wheel is the best of the three. It is now known that the rotatable wheel reduces ramp impact *more than one-half*, as compared with a shoe of the same weight and at the same *train* speed. The comprehensive practical experience alluded to above proves that this is as great a reduction of impact as has any practical significance. By a series of full size tests extending over nearly two years, the writer has proved that, as regards electrical contact with ramps, a rotatable wheel is considerably better than a shoe and practically as good as a continuously rotating wheel, ramp pressure being, of course, the same in all three cases.

It is hoped that the foregoing brief review of present conditions is sufficient to indicate more or less clearly that exclusive fixed signalling is wrong in principle; that until recently such signalling was justifiable only as a necessary evil; and that, the necessity having been completely removed, the prompt application of safer methods is urgently needed. It would be a dangerous mistake to continue the habit of saying that a driver's failure to get fixed signals is proof of "carelessness" on his part. Referring recently to two drivers who had just wrecked two New Haven trains by such carelessness (?), Mr. Charles Mellen, the president of that railroad company wisely said, "Let us not blame them," and added that his road proposed helping the drivers by a particular type of cab systems. The two New Haven accidents, Westport and Bridgport, call for cab systems no more urgently than the numerous class of British wrecks cited above. This American road is now taking active measures to apply the *only* cure for such wrecks, viz., a cab system. How many British roads are doing so?

Until quite recently, railways had one valid excuse, *but only one*, on which to base their failure to instal cab systems, and that was the fact that every cab system ever proposed possessed some *serious* fault. It is not only demonstrable, it has been repeatedly demonstrated, by wrecks, that exclusive dependence upon fixed signals ought to be abandoned as soon as equally practical and reliable cab systems can be obtained. Modern engineering progress has completely satisfied this requirement, and so destroyed all justification for continued reliance on exclusive fixed signalling. So inferior, indeed, is such signalling that the Chemin de Fer du Nord of France was probably right in abandoning it more than twenty years ago; even though, owing to the backward state of cab systems then, the "Nord" was compelled to adopt a cab signal which is extremely faulty, as compared with such as are now available. The Paris, Lyons and Mediterranean Railway a short while ago decided to try a cab system (signal form) throughout three hundred miles of double track. In the United States, a board of experts, after *nearly five years*, careful study, officially declared that the railroads ought to be given to understand that the cab system (train-stop form) "must be developed by them as rapidly as possible." The need for cab systems in the United States does not by any means arise from conditions peculiar to that country, but from conditions which America and England possess in common. How much further waste of shareholders' money and workers' and passengers' lives must be occasioned in Great Britain by *clearly preventible wrecks* before the United Kingdom ascends to the level of the United States and France in this extremely important matter?

# THE MANUFACTURE OF ARMOUR-PIERCING PROJECTILES*

By General Leandro Cubillo

SINCE the inauguration of the era of armoured vessels by the equipment of the French frigate *Gloire*, the necessity has been imposed of designing guns of such power as to impart sufficient energy to their projectiles to enable them to break down the resistance offered by the armour. In addition, it was also required that the material of which the projectile was made and its form should be such as to produce complete perforation of the plate. Though the material of which the armour plates were made at the time of their first introduction would present no difficulty of attack with the means which metallurgical science at the present day places at our disposal, that was not, by any means, the case fifty years ago. It was no easy matter to pierce a plate of forged or rolled iron by direct or oblique attack with cast iron balls or with cylindrical or ogival projectiles, even if of crucible steel, such as was then obtainable. Spherical projectiles were discarded and cylinders with ogival points, and even cylinders with flat heads were tried, as designed by the celebrated late Sir Joseph Whitworth, who applied his mechanical genius to the solution of many problems in metallurgy and mechanics, particularly those bearing on the construction of artillery.

The Palliser projectiles, which were the first to be used with success against armour plate, were made of cast iron, the ogival point being cast in a metal mould and the cylindrical portion in ordinary refractory sand. By this means it was endeavoured to give extreme hardness to the material forming the point, that being the part required to perform the actual work of piercing the armour plates. The reason why a cast iron of definite composition on being cooled rapidly becomes a brilliant white and of extreme hardness is now well known, but forty or fifty years ago the influence of silicon in counteracting the formation of white cast iron, and that of manganese and sulphur in promoting it were entirely unknown. The melting mixtures from which the best Palliser projectiles were obtained were the result of experience on the part of foundrymen, and the various kinds of iron used in their composition were denoted by classification numbers. In a certain way the manufacture of the old Palliser projectile was similar to that of modern ones, but the operations involved in making the former were extremely short and simple. The casting of the point in a metallic mould gave to the projectile at once both its final form and the necessary thermal treatment which hardened it. In the manufacture of the projectiles of the present day the process is infinitely longer and more complicated, but in principle it is the same, and approximates the more to the Palliser process if the projectile, instead of being forged, is simply cast and subjected afterwards to thermal treatment. Certain rules based on experience contributed to good results in the manufacture of Palliser projectiles. For instance, the thickness of the metallic mould had to be equal to half the diameter of the projectile. The author is inclined to dwell on the subject on account of having himself inaugurated and taken charge of the manufacture of such projectiles for several years at the Arsenal of Trubia. When materials distinct from ordinary wrought iron began to be used in the

*Read at Brussels meeting of Iron and Steel Institute.

manufacture of armour plate the Palliser projectiles were no longer capable of piercing them, and failed completely against the Schneider plates of homogeneous steel, as well as the English compound plates and those hardened by the Harvey or the Krupp processes. The same progress in metallurgical science which made it possible to improve the armour plate material contributed also by degrees to the perfecting of projectiles. Advantage was taken of the property of chromium, which increases the hardness and toughening capacity of the steel in a higher degree than carbon, but without increasing the brittleness, and a certain proportion of this metal was added to the material used in the manufacture of projectiles.

For some time the Holtzer projectiles had a great reputation; these were made of chromium steel, and were greatly in demand for testing the quality of armour plate, but when the ternary and quaternary steels came to be employed in the manufacture of the plates, the surfaces of which were cemented to a certain depth and afterwards hardened, even the chromium steel projectiles, tempered and hardened as they were to an extraordinary degree, could not pierce the plates. Fortunately the invention of the cap again gave the preponderating advantage to the projectile in the struggle which for fifty years has been maintained between it and the armour plate.

When the Holtzer projectile was first introduced, about 1886, there were no plates which could withstand it in any way. During the decade 1880-1890 the compound armour plate was in general use in England; in other countries of Europe and in America both compound and steel plates were in use, against which, as already stated, the Palliser projectiles were harmless, especially the compound plates. In the following decade, 1890-1900, the cap for projectiles came into use, and by 1896 it was generally acknowledged that it was very difficult to pierce the Harvey plates without that attachment. The United States adopted capped projectiles in 1900, and it was estimated that thereby the penetrative capacity of the projectile against Harvey plates was increased by 15 to 20 per cent., but, on the other hand, no effect was produced at angles of greater obliquity than 20° from a right angle, that is, at an angle of 70° with the face of the plate. Nevertheless, the testing of plates with uncapped projectiles continued up to 1904, though from 1901 the importance of the cap was daily becoming more manifest because the points of the projectiles without that attachment broke on striking the hardened plates. The cap protected the point on the first impact, and, though the exact action has not yet been satisfactorily explained, it is certain that, whereas unprotected projectiles are warded off by the plate, those with caps easily penetrate and pierce it completely. However, it is not necessary to go further into the history of this accessory of the modern piercing projectile, and it is enough to say that its importance has become more and more recognised and that its form and manner of attachment have changed considerably since the time of Johnson down to the most modern hollow types produced by Sir Robert Hadfield's firm, which give such excellent results when fired at an oblique angle.

Composition and Physical Properties of the Material.—As mentioned in the first part of the paper, the material out of which projectiles are manufactured is usually a ternary steel; sometimes a quaternary steel is used, which, in the opinion of the author, is superior to the former. The ternary steel is formed by an admixture of chromium and a quaternary by the addition of chromium and nickel, and the proportion of the chromium in the ternary mixture and that of chromium and nickel in the quaternary are such that, notwithstanding the relatively high percentage of carbon in the former case, the two types of steel belong to the pearlitic series—that is, their critical points, both in heating and in cooling, are above 500° C. As specimens of the two types of material, the chemical

analyses of two ternary and one quaternary steel, as used at Trubia for the manufacture of projectiles, are given in the following table:—

*Chemical Analysis.*

| C. | Mn. | Cr. | Ni. | Si. | S. | P. |
|---|---|---|---|---|---|---|
| Per Cent. | Per Cent. | Per Cent. | Per Cent. | Per Cent. | | Per Cent. |
| 0·848 | 0·381 | 2·311 | — | 0·163 | — | 0·020 |
| 0·818 | 0·294 | 2·371 | — | 0·220 | — | 0·030 |
| 0·485 | 0·582 | 0·749 | 2·545 | 0·400 | — | 0·040 |

*Tensile Tests.*

| Nature of Test. | Elastic Limit. | Breaking Strain. | Elongation. | Observations. |
|---|---|---|---|---|
| | Tons per sq. in. | Tons per Sq. In. | Per Cent. | |
| Along the grain .. | 21·28 | 45·53 | 20·5 | Chromium steel for a 15 centimetre projectile, annealed. |
| Across the grain .. | 19·35 | 38·36 | 21·0 | |
| Along the grain .. | 35·47 | 51·11 | 18·5 | Chromium steel for a 15 centimetre projectile, quenched in oil and tempered. |
| Across tho grain .. | 33·54 | 43·53 | 13·0 | |
| Along the grain .. | 57·76 | 67·08 | 19·0 | Chromium nickel steel for a 15 centimetre projectile, quenched in oil and tempered. |
| Across the grain .. | 56·01 | 65·79 | 11·5 | |

The examination of the chemical analyses confirms what has just been explained, that is that both the ternary and quaternary types of steel are pearlitic. For the chromium steel it would be necessary that the percentage of the added element should be about 4 per cent., the carbon being somewhat above 0·8 per cent., in order to bring the material within the range of the martensitic steels. With regard to the chromium-nickel steel, it is necessary to reduce the chromium and carbon percentages in order to retain the steel within the pearlitic range. The great superiority of the quaternary steel over the ternary will readily be seen on examining the tensile tests. In short, the elastic limit particularly and the yield-point are considerably increased, the ductility remaining the same, thus affording evidence of the great improvements due to the addition of chromium and nickel to the ordinary carbon steel.

The heating and cooling curves of the two kinds of material used in the manufacture of piercing projectiles were determined in the laboratory at Trubia, a Le Chatelier-Saladin pyrometer being used for the purpose. The curve for the chromium steel (Fig. 1) exhibits during heating one critical point only, Ac3,2,1 at 783° C., the corresponding reverse point Ar3,2,1 occurring at 730° C.; the difference due to lag is 53° C. If the point Ar3,2,1 of this steel be compared with the point in a steel containing the same percentage of carbon there is in the latter, according to Carpenter and Keeling, a difference of 44° C., which represents the amount by which the point has been lowered, due to the presence of 2·371 per cent. of chromium. In the chromium-nickel steel it will be noted that the point Ac3,2,1 occurs at 741° C. (Fig. 2), whereas the corresponding point Ar3,2,1 occurs at 636° C., the difference being 105° C., indicating an extraordinary degree of lag. In a steel with the same percentage of carbon the corresponding point on

cooling is at 777° C., or a difference of 141° C., which brings out very clearly the influence of the chromium and nickel, especially that of the nickel, in lowering the critical point on cooling. The determination of these critical points supplies the necessary data for fixing the temperatures at which the subsequent heat treatment should be performed in the further processes of manufacture.

PROCESS OF MANUFACTURE.—The next question is what are the operations necessary for the entire manufacture and finishing of a piercing projectile after the melting operation. Is forging an absolute necessity, or, on the other hand, can the projectile be cast in its approximate final form, and require no further operation to finish it than the necessary heat treatment? Theoretically it has been proved that a metal free from blowholes derives all its physical and mechanical properties from its chemical composition and the subsequent heat treatment. If, therefore, the steel founder can be relied upon to produce an absolutely sound metal, forging can be dispensed with, for, as the author has already pointed out in his previous paper on the manufacture and treatment of steel for guns, the principal object of forging is not so much to give the pieces their final shape as for the purpose of transforming the crystalline structure, due to casting in metal moulds, into the fine-grained and almost amorphous structure, which a material with the necessary physical and chemical properties must possess. It may be mentioned that the well-known firm, the Hadfield Steel Foundry Company, Sheffield, have until recently manufactured high-class piercing projectiles by casting only, without any forging operation, which gave uniformly excellent results, and they can supply such projectiles, if preferred. At present, however, they forge all their armour-piercing shells.

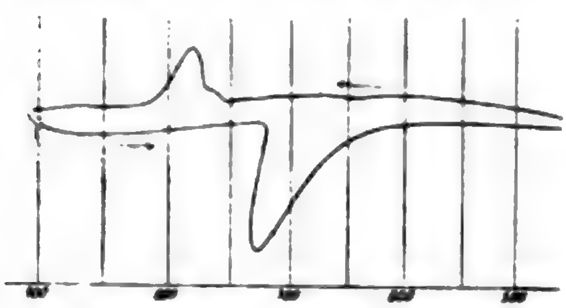

FIG. 1.—HEATING AND COOLING CURVES OF THE TERNARY STEEL.
Chromium, 2·371 per cent.; Carbon, 0·819 per cent.

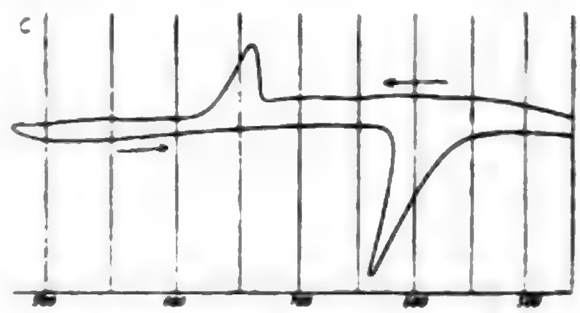

FIG. 2.—HEATING AND COOLING CURVES OF THE QUATERNARY STEEL.
Chromium, 0·749 per cent.; nickel, 2·545 per cent.; Carbon, 0·485 per cent.

At Trubia, as in most factories engaged in the manufacture of piercing projectiles, forging forms a part of the entire process of manufacture. In any case the annealing of the metal is indispensable after casting without forging, or after forging, if forging is practised. If the metal has simply been cast, annealing has the effect of restoring the molecular equilibrium, which will have been destroyed by the unequal cooling of the steel in the metal mould, and the equilibrium imparted by annealing puts the piece into good condition to undergo the subsequent heat treatment. As regards hardening and tempering, these are absolutely indispensable operations, but the final hardening of the point presents the principal difficulty in the manufacture of the projectile. At Trubia projectiles undergo two hardening processes—the first by quenching in oil, followed by tempering, and the second when the mechanical work upon the projectile is completely finished, with the exception of putting on the saltire. This final hardening operation is the more important of the two, being that which gives to the point of the projectile that superior hardness which enables it to attack the hardened surface of the plate, and completely pierce it, whether striking it direct or

at an oblique angle. The remainder of the projectile does not require to have the same degree of hardness, since, once the point has penetrated the body of the projectile passes the hole without difficulty, and serves no other purpose than to impart the energy required to complete the work of total perforation. If it is not possible to harden the point equally throughout its whole thickness, it must at least be externally of an intense hardness, which may gradually diminish towards the interior, as in the case of the Palliser projectile, where this effect was produced by casting the point in a metal mould.

Concerning the tempering of the point of piercing projectiles, with a view to removing to some extent the effect of the unstable equilibrium due to hardening, the practice is not to temper them after hardening, as it is considered preferable to run the risk of possible fracture rather than reduce the hardness in any degree. The whole projectile is, however, submitted finally to a gentle heat treatment which, as far as possible, ensures it against fracture due to any sudden and extreme changes of atmospheric temperature to which it is likely to be exposed.

At Trubia the steel intended for the manufacture of piercing projectiles is melted in the open-hearth furnace. On the Continent and in England crucible steel is used for the purpose, because the crucible process has always been considered the best for obtaining a material of the greatest purity, as required for this very special product; but it is possible to produce in the open-hearth furnace a steel so low in phosphorus and sulphur as to be serviceable for making projectiles. For that purpose the very best and purest materials, such as Swedish iron and puddled blooms of Bilbao hæmatite iron, are employed. The ferro-manganese, ferro-chrome, nickel, and ferro-silicon used as additions are the purest obtainable of this class of metals. For the oxidation of the charge Campanil ore is used of the best quality to be found in the Bilbao district. The melting and refining processes are conducted with the greatest care, so as to avoid oxidation of the bath, and should it become oxidised, deoxidisers are added at the end of the heat. The ferro-chrome and nickel additions before charging are preheated in a special furnace alongside of the melting furnace, so as to avoid cooling the bath. The charge is not completely decarburised, but is tapped when the calorimetric analyses at the end of the refining operations indicate that it has reached the requisite degree of carburisation, taking into account, of course, the carbon in the ferro-chrome added to the bath

The metal, when finished, is poured into moulds of square section with rounded corners. They are lined at their upper ends with refractory material, intended to keep the metal fluid at the top as long as possible, in order to feed the shrinkage of the steel as it cools, thus largely preventing pipe. The author still maintains his opinion, previously expressed, that, provided the ingots are free from blowholes and poured in moulds lined at the top, compression does not materially improve the physical and mechanical properties of the steel, the only substantial advantage being a saving of metal. The author's attention was lately drawn to the series of experiments carried out by Heyn and Bauer at the Gross-Lichterfelde Testing Laboratories in order to determine what improvements in the physical properties of the steel are effected by the Harmet process of fluid compression. The investigators adopted the only rational method for the study of the question—that is, they divided the charge into two equal parts, one of which was cast into ingots in ordinary metal moulds and the other into ingots which were compressed by the Harmet process. Three kinds of steel were examined—medium hard, hard, and hard nickel steel. From these three classes of compressed and uncompressed material sections from the top, middle, and bottom of the ingots were rolled in I-girders, from which test-pieces were cut and subjected to the usual mechanical tests, the results of which

show in general that the girders rolled from the sound part of the uncompressed ingots were not inferior in any respect from those rolled from the compressed ingots.

The forging of piercing projectiles is an operation requiring the greatest care. Taking account only of the carbon percentage the material may be classed as hard steel, and more completely so when it is a chromium steel. It is of great importance that the ingot should be preheated before introducing it into the reheating furnace, and even then it is desirable that the furnace should be at a sufficiently low temperature. Unless these precautions are carefully observed the ingot is likely to fracture transversely, as has more than once happened within the author's experience in Trubia. The reheating having been carefully performed in this manner, the ingot of 2½ tons is forged under the press until it is circular in section throughout its length, and of a diameter which exceeds that of the finished projectile by just so much as to allow the necessary machining. The greater part of the head is then removed by cropping. The blank is then reheated and the point is forged. The annealing operation is now necessary to restore to the material the conditions of equilibrium which have been changed by the work of forging. The annealing is performed at the temperature deduced from the cooling curves, and the operation being complete, the blank is passed to the machine shops.

In the machine shop projectiles are first cut to length, and then bored out in order to form the cavity intended to receive the explosive charge. At the same time the cylindrical exterior and the point are turned up in the lathe, and the projectile is then ready for hardening in oil.

HARDENING AND TEMPERING.—Though it is not necessary that the whole projectile should receive the intensive thermal treatment which is required to give to the point the hardness necessary for piercing, it is considered, nevertheless, that the hardening of the entire projectile in oil is extremely beneficial. As the result of this operation, which must be followed by tempering, the material acquires an extremely fine grain, and certain notable physical properties, as shown in the table giving the results of the tensile tests. If the three characteristic tensile properties of the chromium steel are good, the corresponding properties of the chromium-nickel steel may be said to be quite surprising. It is inconceivable that any other material than the chromium-nickel steel can show a combination of properties equal to the elastic limit, the yield point, and the elongation per cent. of this steel, particularly when it is considered that this latter amount is measured in a length of 2·4 inches.

For the oil-hardening a vertical furnace, heated by a gas-producer, is provided. The projectile is heated about 100° above its critical point, the temperature being measured by a Le Chatelier pyrometer. The hardening is then performed in an oil-bath of a capacity equal to ten times the weight of the projectile. The tempering is carried out at a temperature of 400° to 500° C.

Having been oil-hardened and tempered, the final treatment is given to the point, and the projectile is now finished with the exception of fitting the saltire.

After receiving the final heat treatment the projectiles remain for about eight or ten days in the hardening department, at the end of which time, if they have not fractured, their capacity to resist sudden changes of temperature is tested. The object of this test is to ascertain whether a projectile can withstand, without breaking, a sudden change of temperature of about 60° to 70°, which is a greater variation than is likely to occur in extreme climates. The test is performed by placing the projectile for a certain time in boiling water until it attains that temperature, and then plunging it suddenly in cold water.

BREAKAGES.—Though it very rarely happens that projectiles fracture on being hardened in oil, fracture may occur after the point has undergone the final heat-treating operation. In

view of the very drastic nature of this treatment of the metal, which, if it contained the simple equivalent of carbon, would be classed as very hard, and considering also the thickness of the point where it joins the cylindrical portion, it is difficult to carry out the hardening operation in such a way as not to produce internal stresses. Special precautions are necessary, on account of the fact that the operation introduces a state of unstable equilibrium in the material and is not followed by a tempering process, which would relieve these abnormal stresses. The effect of this very rapid quenching of the surface, though somewhat relieved by the heat yielded up by the internal layers, cannot fail to create considerable tensile and compressive stresses, sometimes of a magnitude sufficient to overcome the cohesion of the molecules and produce fracture. When this delicate hardening operation was first practised, it was a frequent occurrence for the projectile to crack, but that rarely happens now, and when it does the cracks only become visible after several days. Sudden changes of atmospheric temperature must be avoided, the slight stresses due to such changes, when added to those caused by hardening, being sometimes sufficient to produce fracture. The cracks occur in the point at a greater or less distance from the extremity, and in a plane normal to the axis. Some idea may, therefore, be formed of the enormous stresses in the metal produced by hardening. It is within the author's recollection that on a winter morning, when the temperature suddenly rose several degrees, the points of six or eight projectiles which had been hardened about eight days previously developed cracks. Such cracks seldom occur in the plane of the diameter, but almost always vertically through the point. Fracture is not always due to physical causes only, as it has been proved that by diminishing the percentage of manganese, the number of breakages is also diminished.

THE MANUFACTURE OF THE CAP.—Since the introduction of cap projectiles the advantage has been recognised of making the cap of a softer material than that of the projectile, and it is now considered good practice to use an extra mild steel. These opinions notwithstanding, a quaternary steel is used at Trubia, though with a lower percentage of chromium and nickel than that contained in the projectile steel. The following is the composition of a steel for caps, which has given excellent results :—

| | Per Cent. |
|---|---|
| Carbon .. .. | 0·40 to 0·45 |
| Silicon .. .. | 0·10 to 0·15 |
| Manganese .. .. | 0·50 to 0·60 |
| Phosphorus .. .. | 0·3 |
| Sulphur .. .. | 0·3 |
| Chromium .. .. | 0·30 to 0·35 |
| Nickel .. .. | 1·30 to 1·50 |

The tensile properties are shown in the following table :—

| | Elastic Limit. | Breaking Strain. | Elongation. |
|---|---|---|---|
| | Tons per sq. in. | Tons per sq. in. | Per Cent. |
| Annealed after forging .. | 24·41 | 47·08 | 10 |
| Hardened in oil and tempered .. | 40·63 | 53·53 | 12 |

The steel for the caps is melted in an open-hearth furnace, and is composed of the best materials, the operations of melting, refining, and tapping being performed with the same degree of care as is bestowed on the material of the projectiles. The steel is forged in round bars after removal of all surface cracks from the ingot, and is then annealed and cut into short lengths convenient for stamping. After stamping the caps are oil hardened and tempered in the same manner as the projectile, and then undergo the final thermal treatment.

The heating and cooling curves of the steel for the caps is shown in Fig. 3,

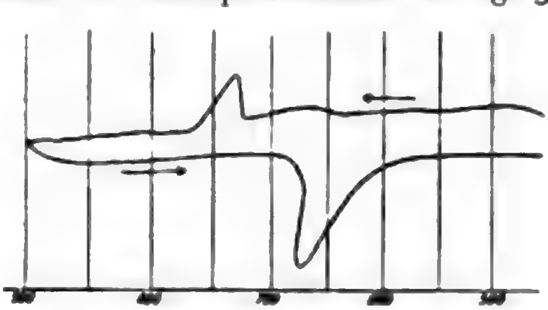

FIG. 3.—HEATING AND COOLING CURVES OF STEEL FOR CAPS.

FIG. 4.—THREE 110 LB. SHELLS SHOWING RESULTS OF TEST. THEY WERE FIRED AT A SCHNEIDER NICKEL STEEL PLATE 7·1 INS. THICK AT A RANGE OF 320 FT. ONLY THE CHROMIUM-NICKEL STEEL SHELL (NO. 2) PENETRATED THE PLATE WITHOUT BREAKING.

from which it will be seen that the critical points in heating and cooling are not more than 50° C. apart.

FIRING TESTS.—After having described the manufacture of piercing projectiles it may be of interest to give some account of their behaviour on the testing ground. Up to the present the only tests carried out against chromium-nickel steel plates hardened by the Krupp process with illuminating gas have been performed with projectiles of 15 centimetres, or say 5·9 inches calibre.

Many tests have been performed, of which those carried out on the two days, September 26th and December 17th, 1905, will be more particularly described. On the first of these days a Schneider plate, 180 millimetres (7·1 inches) thick, was under fire. The plate, which was of nickel steel with a small percentage of chromium, and hardened by the Krupp process, was placed at a range of 100 metres (320·7 feet) from the mouth of the gun, and was fixed at right angles to the path of the projectile. The tests on both days were performed by a quick-firing gun, which discharged a projectile of 50 kilogrammes (110·37 lbs.). The result of the first day's firing is summarised in the table below.

Of the three projectiles the chromium-nickel steel projectile was the only one which passed through the plate with-

| No. of Discharge. | Type of Projectile. | Velocity of Impact. | Energy. | Diameter of Perforation. Entry. H. | Entry. V. | Exit. H. | Exit. V. |
|---|---|---|---|---|---|---|---|
| | | Feet. | Foot-tons. | Inches. | Inches. | Inches. | Inches. |
| 1. | Chromium steel | 2243 | 3923 | 6·7 | 6·3 | 11·8 | 9·05 |
| 2. | Chromium nickel steel | 2291 | 4085 | 5·9 | 5·9 | 9·05 | 10·6 |
| 3 | Chromium steel | 2203 | 3450 | 7·8 | 6·7 | 11·4 | 14.96 |

FIG. 5.—SHOWING RESULTS ON A CHROMIUM STEEL AND A CHROMIUM-NICKEL STEEL SHELL AFTER PIERCING SCHNEIDER PLATE. VELOCITY 2147 AND 2148 FT. RESPECTIVELY.

out either breaking of undergoing deformation—even the copper saltire was retained. No. 1 projectile broke into several pieces, of which twelve were recovered, the largest being the point, weighing 18 kilogrammes. Of projectile No. 3 fourteen pieces were recovered, the largest also being the point, weighing 14 kilogrammes. The three projectiles are shown in Fig. 4. Each projectile pierced a clean hole through the plate. In this test the superiority of the chromium-nickel projectile was clearly manifest, as one would expect from the marked superiority of its tensile properties.

On the second day, December 27th, another Schneider plate of the same thickness was fired at, the only difference being that, instead of placing it vertical to the line of firing, it was set at an angle of 10° 20′. The result of the test is summarised in the table on the next page.

Both the first and second projectile pierced the plate. As in the previous test, the chromium-steel projectile broke into many pieces, of which ten were recovered, weighing altogether 33 kilogrammes. The chromium-nickel steel projectile was recovered intact, at a distance of 8,200 to 9,830 feet. The point sustained a light conchoidal fracture, as shown in Fig. 5.

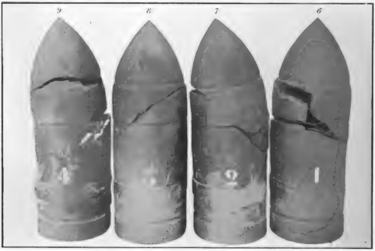


FIG. 6.—RESULTS ON SHELLS OF CHROMIUM-NICKEL STEEL FIRED AT SAME TYPE OF PLATE BUT AT LOWER VELOCITY, 1867 FT.

| No. of Discharge. | Type of Projectile. | Velocity of Impact. | Energy. | Diameter of Perforation. | | | |
|---|---|---|---|---|---|---|---|
| | | | | Entry. | | Exit. | |
| | | | | H. | V. | H. | V. |
| | | Feet. | Foot-tons. | Inches. | Inches. | Inches. | Inches. |
| 1. | Chromium steel | 2188 | 3721 | 5·9 | 6·3 | 9·05 | 9·8 |
| 2. | Chromium nickel steel | 2147 | 3587 | 6·3 | 6·3 | 11·8 | 7·87 |

In view of the excessive energy of the chromium-nickel steel projectile, which has travelled a great distance after piercing the plate, tests were afterwards made with a lower velocity of impact. The velocity was reduced to 1,867 feet, the energy being 2,705 foot-tons. The only difference noted was that at these low velocities the chromium-nickel projectile broke, but only into few pieces, and some of them, as shown in Fig. 6 (No. 8), were only broken into two parts. The energy of impact of that projectile was 2,911 foot-tons. All four projectiles shown in Fig. 6 were of chromium-nickel steel.

# THE FIRST DIESEL LOCOMOTIVE

By Percy R. Allen, Assoc.M.Inst.C.E., M.I.Mech.E., &c.

THE completion of the first main line internal combustion Diesel Locomotive may be regarded as an event of considerable importance in internal combustion engine circles. The engine was ordered some time ago by the Central Railway Department of the Prusso-Hessian State Railway, and was supplied by the Gesellschaft fur Thermo-Lokomotiven, a company established by Messrs. Sulzer Bros., of Winterthur, but having their chief offices at Ludwigshaven. The framework and body of the locomotive were built at Messrs. Borsig's locomotive works at Berlin, but the Diesel engines and gearing connected with them were built at the Winterthur works of Messrs. Sulzer. The design of the engine was worked out jointly by Messrs. Sulzer Bros. and Oberbaurat A. Klose, of Berlin, in consultation with Dr. Diesel. It is interesting to note how the designers have met the difficulties of the problem set before them. Most other internal combustion locomotives that have been constructed have either transmitted the power to the wheels through gearing or have used some kind of automixe system in which the engine is used to drive a dynamo, which in its turn works motors on the axles.

In the present instance the connecting rods of the main engine act directly on two cranks on an intermediate crankshaft which work the driving wheels by outside connecting rods, a similar arrangement being now generally employed on many large electric locomotives. This, of course, necessitated the engines being of a directly reversible type, and although this introduced apparent complications in the valvegear, the designers consider that this is amply compensated for by the simplicity in the transmission.

As will be seen from the longitudinal section in Fig. 5 the locomotive is really equipped with two distinct engines the main engine driving the crankshaft being a four cylinder Sulzer Diesel two cycle motor, but in addition to this there is an independent Diesel set driving a twin multi-stage air compressor. The

FIG. I.—SHOWING GENERAL APPEARANCE OF THE DIESEL LOCOMOTIVE.

idea of having this auxiliary supply of compressed air for starting and manœuvring was foreshadowed in some earlier patents. In the locomotive as actually constructed, the auxiliary compressor is a distinct entity, and is of 250 h.p., about one quarter of the power of the main engines. This auxiliary compressor is used to keep a nest of air bottles charged up and from these the air in led to the main engine.

The general appearance of the exterior of the locomotive is shown in Fig. 1. The driving wheels are in the centre of one long frame carried by swivelling and traversing bogies at each end. As the engine was designed for a comparatively high speed the frame is of a heavy plate section, and while in itself very stiff, is provided with a very complete system of springs to absorb vibration.

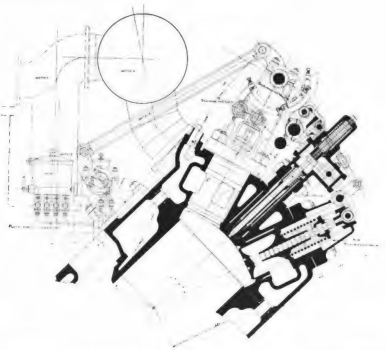

FIG. 2.—DETAILS OF FUEL VALVE AND TWO AIR-SCAVENGING VALVES.

When starting it is usual to run the locomotive entirely by compressed air until a speed of about six miles an hour has been reached. The compressed air is then cut off, and the main engine run purely as a two-cycle Diesel engine, the speed and power being regulated by the fuel admission and the injection air.

The total length of the body is about 54 feet 6 inches, and the driving wheels are 68¾ in. in diameter, spaced 12 feet apart. The centres of the bogies are 34 ft. 6 in. apart. The main engine works at 304 r.p.m., which gives a speed of 62 miles an hour, so that in every way the engine may be considered as a competitor to an ordinary

main line steam locomotive. The cylinders are set diagonally bolted to a strong crank casing extending between the two main frames, the casing being of cast steel and carrying three bearings for the crankshaft. The four cylinders are 15 in. diameter with a stroke of 21·7 in. Each pair of cylinders work on to one crank pin, and the two cranks are set at an angle of 180 deg. to each other. The fuel valve is placed in the middle of the cylinder head, and the two valves to admit the scavenging air are symmetrically placed on each side of it. This can be seen in Fig. 3. There is also another valve in the cylinder head to admit the compressed air for starting. The pressure of the starting air is given by the makers as being 712 lbs. to the sq. inch, absolute, and the scavening pressure 20 lbs. absolute, while the pressure of the injection air varies from 710 lbs. to 1,000 lbs., absolute. Apparently no trouble has been experienced from these comparatively high pressures.

As the engine is constructed to work on the two-cycle principle there are no exhaust valves in the cylinder heads to complicate matters when reversing, and the exhaust takes place in the usual two-cycle manner by a belt of ports in the lower part of the cylinder. A portion of the exhaust aperture can be seen in Fig 2, which shows in detail the fuel valve and the two air-scavenging valves. The mechanism for actuating these valves is shown separately in Fig. 3. The valves themselves are directly moved by rolling cams connected by eccentric rods "b b" to eccentrics "a," which can be shifted on the crankshaft relatively to the crank by means of the lever "e" connected by long rods "d" to quadrants and handwheels at the driving end of the car. The amount of opening of the fuel valve can be varied by means of the arrangement shown in Fig. 3. The fuel pumps for supplying the oil under pressure are worked off the valvegear and the delivery of these is adjustable by hand, but these are not shown on the diagrams.

Owing to the fact that the main engine has to run purely as a compressed air engine the mechanism for admitting the compressed air is of a somewhat more elaborate nature than it would be if it was simply necessary to admit compressed air to turn the engine a few revolutions either way, and the makers have adopted a peculiar and very ingenious arrangement by which a constant lead can be secured as the

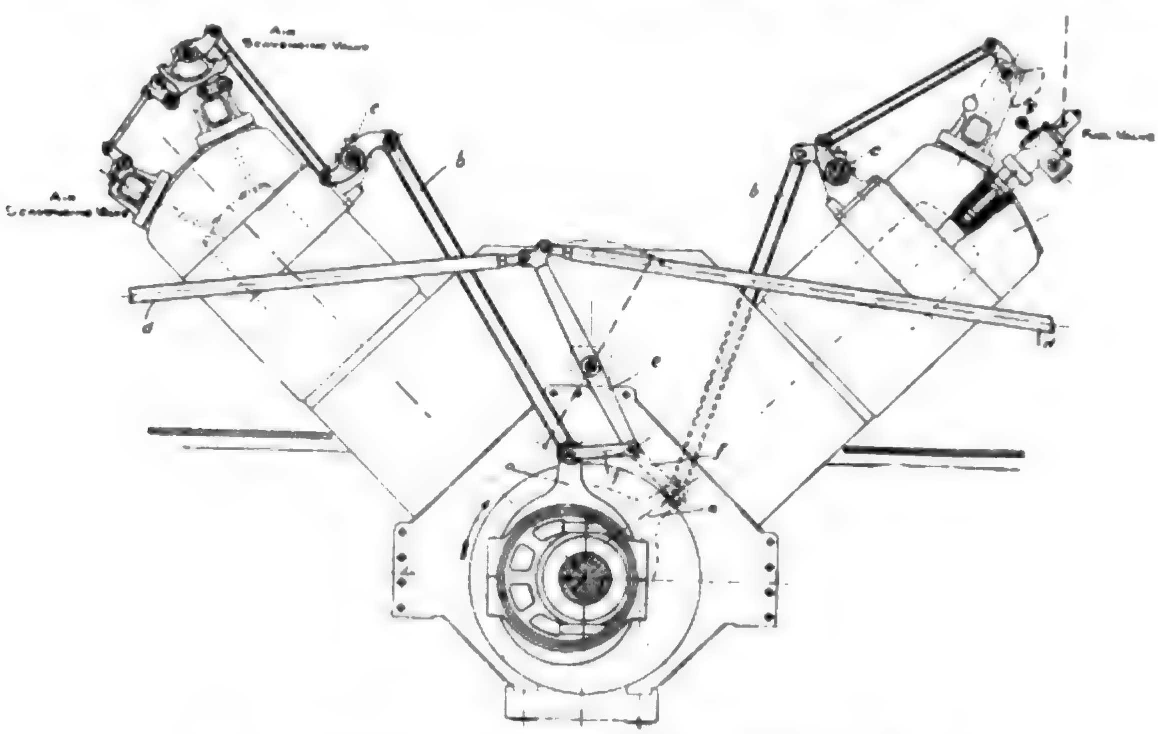

FIG. 3.—ACTUATING MECHANISM FOR FUEL AND SCAVENGING VALVES.

amount of air admitted is varied. It will be seen in Fig. 4 that the air before passing on to the admission valve in the cylinder passes through a valve box containing a valve entering and leaving by the pipe "k." This valve is pulled off its seat by the action of bell crank levers acted on by cams by hand to control the amount of opening.

Situated between the four cylinders of the main engine there are two double acting piston pumps and a multiple stage air pump. These are driven from the connecting rods by means of links and rockers. The

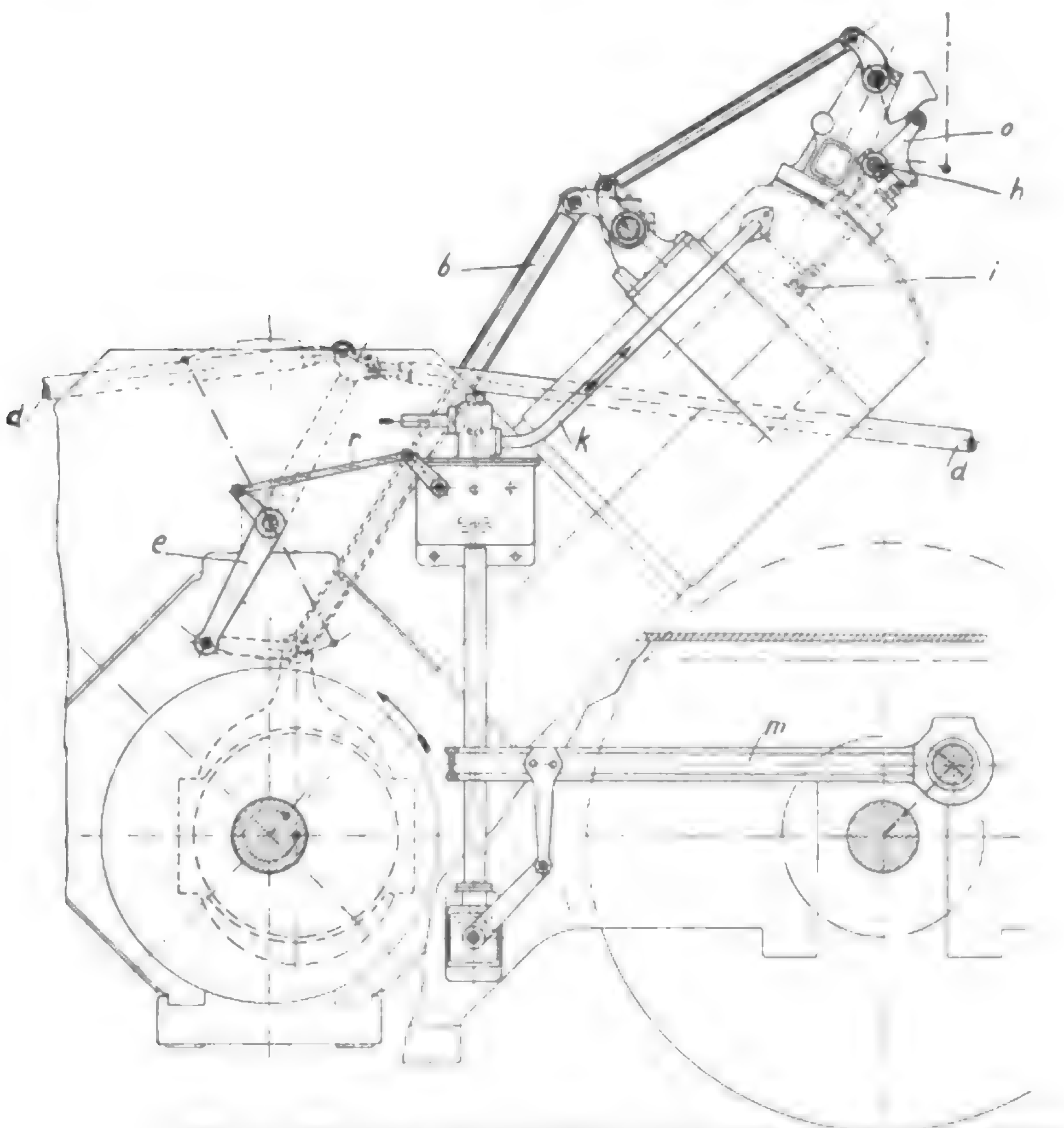


FIG. 4.—SHOWING COMPRESSED AIR ADMISSION ARRANGEMENTS.

on the top of a vertical shaft which is caused to revolve by means of a pair of bevel wheels worked by means of a crank off the side rod "m." The air valve "i" in the cylinder is controlled by the bell crank lever "o," which is mounted eccentrically on the shaft, and the degree of eccentricity can be varied compression air pump acts as a reserve for the auxiliary compressor, and if for any reason that machine should fail the air pump on the main engine can supply sufficient injection air up to a certain extent.

The auxiliary Diesel engine and compressor, as shown on the left hand

end of Fig. 5, is also of the two cycle Diesel type, with the cylinders 12 in. in diameter by 15 in. stroke, and when running normally develops about 250 H.P. The valves are worked by a horizontal camshaft on top of the cylinders driven from a vertical shaft geared to the crankshaft.

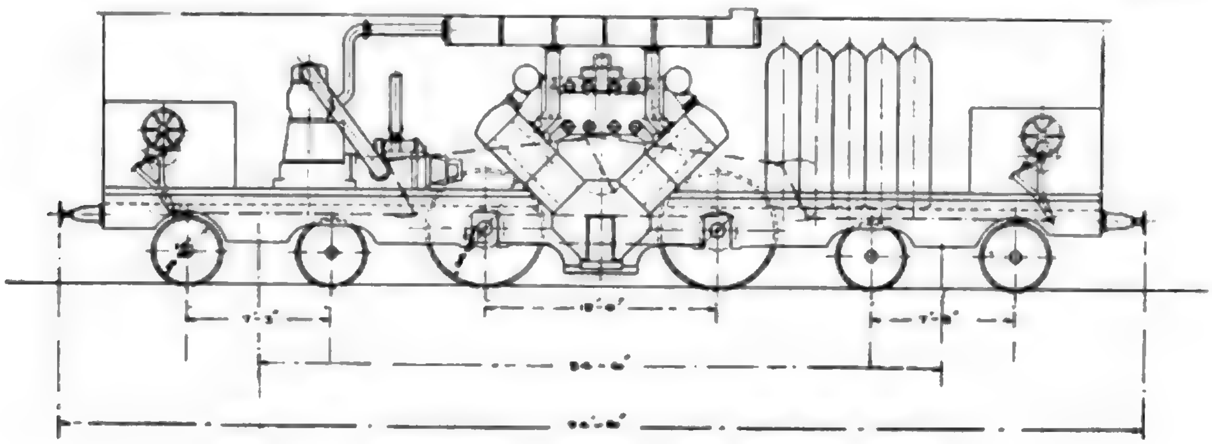

FIG. 5.—LONGITUDINAL SECTION OF THE DIESEL LOCOMOTIVE.

The function of this engine is to drive two multi-stage horizontal air compressors which lie along the floor and are driven off the cranks connected to the working pistons. Each compressor is a three stage one, the first stage nearest the crank case supplying scavenging air and the right hand side of this cylinder feeds air into the smaller cylinder for the final compression. Inter-stage cooling arrangements are provided and the air is finally distributed either to the starting air chamber or to the reservoir of bottles. The air for starting up the auxiliary engine in the first instance is taken from this reservoir. The exhaust discharge both from the auxiliary and the main engine passes into the atmosphere through an aperture in the top of the cab.

Nearly all the bearings and moving parts about both engines are supplied with forced lubrication by suitable pressure pumps. The oil fuel is passed through a filtering chamber before it reaches the fuel pumps proper. Suitable pumps are provided for circulating the jacket and piston cooling water, and there are other hand-worked pumps in the cab for charging the pump systems up before starting. A Westinghouse compressed air brake acts on the driving wheels on one side and obtains its supply of compressed air from a separate reservoir fed by the intermediate stage of the auxiliary engine compressor. The equipment of the cabs at each end of the engine are identical and consist of reversing gear for shifting the eccentrics, the necessary arrangement for controlling the starting and fuel valves, the regulation of the fuel pumps, the air brake, sanding gear, the whistle, and a number of gauges indicating the pressure at various parts of the system.

In starting the engine for the day's run the auxiliary engine is first put in motion by admitting air from the reservoir, and as soon as this engine gets into regular operation it is changed over to oil fuel, and begins to deliver air back into the system. The air is then gradually turned on to the main engine, which continues to work as an air engine supply until a speed of about six miles an hour has been reached, when the air is cut off and it works purely as a Diesel engine. Stopping is effected by cutting off the fuel supply and putting the brakes into operation. For reversing, the angles of the eccentrics are shifted in the manner already described, but interlocking gear is applied, so that the fuel supply has to be turned off before the reversing can be effected. The valve gear, although apparently complicated, can be readily followed by anybody who is familiar with the reversible marine engine already built by Messrs. Sulzer,

FIG. 6—THE DIESEL ENGINE COUPLED UP TO ORDINARY ROLLING STOCK, SHOWING RELATIVE SIZE.

and the abolition of exhaust valves, due to the two cycle principle, results in a much simpler arrangement than would be possible with a four stroke engine.

A number of trials were carried out during the autumn of last year on the Winterthur-Romanshorn portion of the line leading from Basel to Lake Constance, at the Winterthur end of which the gradients are quite appreciable. The engine was handed over to the German authorities at the end of last March and proceeded to Berlin via Strasburg, Ludwigshafen, a. Rhein, Worms, Hanau, Elm, Eichenberg, and Nordhausen. During part of the journey the oil engine hauled an express goods train, including its own steam locomotive, and the speed varied from 12½ miles an hour to 62½. The writer had an opportunity of seeing this locomotive when on some of its trial trips, and was rather struck with the general design and commodious arrangements inside. Fig. 6 shows the relative appearance of the engine and its size relative to the other rolling stock.

So far no data appear to have been made public concerning the oil consumption of the engine per ton or train mile, or the repairs or renewals or other operating expenses, but it is generally understood that the engine is now being put through a series of most rigorous tests by the railway authorities. Until this information is forthcoming it is impossible to offer any opinion as to the commercial future of the proposition. A new departure of this kind is bound to call forth a great deal of criticism and exception has been taken in some quarters to the necessity for having such a large auxiliary engine as the complement to the main driving engine, but if it be admitted that the Diesel engine as at present constructed requires a considerable amount of compressed air for reversing and manœuvring, such air supply must be provided for somehow, and it would seem in every way better to use a separate engine than to work a series of pumps deriving their power from the axles.

In any case this experimental engine may be regarded as an exceedingly interesting piece of mechanical engineering, and it is very fortunate that the constructors have been able to combine the expert knowledge of Messrs. Sulzers in Diesel engines with the latest practice of Messrs. Borsig as locomotive engineers, and to have had the assistance of Herr Klose and Dr. Diesel.

# THE HOURS OF LABOUR PROBLEM

**By T. Good**

AFTER more than twenty years of steady agitation among our trade unionists, the eight hours' question is about to be raised as a practical issue, and the sooner both workmen and employers begin to consider its merits and demerits the better. In the engineering trades there is a more particular move for a reduced working week, and this is the subject of negotiations between employers and workmen at the present time. Concurrently, the shipbuilding employers are complaining strongly about men refusing to work overtime, and even losing an abnormal amount of their ordinary working time, involving delays in fulfilling contracts, and the payment by the shipbuilders of penalties in respect of the delays. The whole problem of working hours and shifts may be said to be ripe for solution. Except in the mining industry, there has been little or no revision of working hours or shifts for thirty or forty years. Meantime, industrial and social conditions have materially changed, and the question now is: how can the workmen be given more leisure without detriment to industry? If the matter is not thought out calmly we may drift to a crisis on the eight hours question, with a hasty settlement good for neither labour nor capital.

What many of the active spirits in the labour movement desire, and are working for, is to get some big group of organised workmen—preferably the railwaymen—to undertake a national strike, dislocate the country's commerce, and then persuade Parliament, in the moment of crisis, to legalise the eight hours principle, setting up joint boards to carry it out in the various trades. It was by such procedure that the Miners' Minimum Wage Act was carried.

Apparently the railwaymen and some of the shipyard workers are in a mood just now to move strongly, even to the point of striking, for reduced working hours, and if a blow is struck by one or two groups the movement may spread like wildfire. Every trade may be upset, and after the fight both men and employers may find themselves in the hands of a network of cumbersome committees, or boards of bureaucrats, administering a ridiculous new law.

The demand for reduced working hours is not one to be met, or dismissed, lightly. There is far more in this demand than appears on the surface. Since the last general reduction of hours in the manufacturing and engineering trades industrial conditions have been well nigh transformed. In many cases labour is more casual than it used to be. Men more frequently change their employment, and more often they are obliged to live at long distances from their work. In both ship and house building it is hardly possible for a man to change his residence as often as he changes his employer, and the time occupied in travelling to and from work is often very great.

More important, however, is the question of "speeding-up." The old slack methods of workshop management, under which men could invariably take things easy before breakfast, and enjoyed frequent rest times between jobs without loss of pay, have been superseded by American methods of hustle. Some fifteen years ago, it may be recalled, when Continental

and American competition was getting keen, when home taxation was increasing, and prices were so low that profits shrunk in many cases to vanishing point, our manufacturers had to speed-up their men and machines, or face ruin. Some were ruined. Most of them adopted new methods, and as time has gone on speeding-up has become almost a fine art. In many cases there is more fatigue now in a standard day's work than there used to be in a day plus half a day's overtime.

It is this change of methods that is largely responsible for the reluctance to work overtime nowadays, the abnormal amount of absenteeism, and the current allegations about malingering. It is true that some men do malinger, robbing their societies and disgracing their class. It is true that the craze for amusement is responsible for some men declining overtime. It is true that some men will not work six days a week if their pay rates are high enough to enable them to satisfy their immediate wants by working only four or five days. But the troubles complained of in these respects are more largely due to industrial speeding-up than to any newly acquired laziness. I believe it is a libel on the average British workman to say he has degenerated. The pace is now hotter. A man must not now go to work unless he is fit. In the old days he could go if he did not feel very well. He knew he could take things easy. Men have now to remain at home if they are not quite up to the mark. They have to lie off for more trifling injuries, and at earlier stages of sickness, and they have to get more thoroughly fit and well before they return to the workshops.

In our iron trades, for instance, furnaces are bigger and hotter. Machines run faster, tools are heavier. Appliances need more strength and nerve for their manipulation. Shops are more crowded, more noisy, and more dusty. The managers are in the shops at 6 a.m. instead of 9, as in the old days. Supervision is more strict. Toil is intensified, and hazards are multiplied. Compare, for example, the work and nerve strain of a riveter to-day, working high up on the shell of a *Titanic*, with that of only half a generation ago, when boats were less than half the size, and one has not to go much further for an explanation of the increased absenteeism and reluctance to work overtime.

It is only natural, then, that organised labour should at last be making a move for reduced working hours. This move enlightened employers will meet with open minds, if not in generous spirits. It is for the men and their leaders to make practical suggestions. It is just here, however, that labour is likely to stumble.

Some of the shipbuilding and engineering trade unions recently approached the Employers' Federation on the subject of a reduced working week, and the matter was discussed at the employers' central conference in Sheffield. Several questions, particularly those relating to some possible system of daily work with only one break for meals instead of two, were debated, but it was not possible to come to any definite decision in the knowledge that the Trade Union Congress was formulating a demand for a general eight hour day, and the Labour Party preparing an Eight Hours Bill. A joint conference, however, is to be held, and both the general question of reduced hours and the special one of eight hours will be gone into. Meantime, the Amalgamated Society of Engineers, which has been the leading union in the movement, and unsuccessfully fought a big battle for the eight hours day in 1897-8, has invited its branches and members to prepare information and suggestions for the next joint conference.

If a bargain can be struck between the Employers' Federation and the engineering trade unions, well and good; but one difficulty in the way is that the labour leaders are obsessed with the idea of uniformity. They ask for an all-round eight-hour day. Why? Where is the reason for such a demand? The very principle of the thing is open to a variety of serious objections, while when we get down to working details a multitude of

difficulties present themselves. If the labour leaders are not careful there is going to be a big and disastrous fight on a mistaken issue, and the clock of industrial progress will be put back.

If by mutual agreement the working day could be reduced, bringing in the one-break system, or if the working week were reduced by knocking off the Saturday morning shift, on the basis of slightly extending the other five shifts, labour might substantially increase its leisure without financial loss to industry.

If, for example, the half dozen hours usually worked on Saturday were abolished, the men agreeing to make up two and a-half hours of the loss by working an extra half-hour each evening from Monday to Friday, the employers would save, in the first place, Saturday's steam raising. That would partly make up for the loss of the three or four hours' work in the total week. Again, if the five days were worked on the one-break system, with the staring time made later than at present, there would be a saving of lights on dark mornings. And, again, if the meal break were only half-an-hour, instead of the existing breaks of one hour and one half-hour, the total time for steam to be kept up on each of the five days, though an extra half-hour were worked, would only be ten and a half hours instead of the existing eleven and a-half, plus Saturday morning's six or seven hours. In other words, the working hours would be 50 per week, instead of 53 or 54, and the time of steam up would be only 52½ hours instead of the present 63 hours, or thereabouts. Moreover, under a mutual agreement, and in the possession of a clear week-end from Friday night at about 6, until Monday morning at about 7.30, the men would work better.

It would work out this way: The tandard working week would be 50 hours. That would be a compromise on the eight hours question. The 50 hours would be worked in five days of ten hours each. Saturday would be a clear day off, instead of half a day. That surely would be a solid boon. There would be only one break for meals—half-an-hour for mid-day lunch, the men breakfasting at home before turning out, and then dining in the evening in comfort with their families. The starting time might be 7.30 a.m., and the knocking off time 6 p.m., the total workshop day, including lunch, being only 10½ hours instead of the present 11 hours from 6 to 5, with two breaks.

While labour gained these points—an extra half-hour at home, and an extra meal at home, on each day from Monday to Friday, and the whole of Saturday instead of half of it for holiday—capital would only lose three or four hours' service per week, and that loss would be very nearly, if not fully, balanced by the saving of the whole of Saturday morning's steam, wear, and lights, the saving of half-an-hour's steam on each of the other days, the saving of half-an-hour's lights on winter days, and the better timekeeping of the men through not being required to start till 7.30 instead of six.

Of course, there may be cases where this proposal could not be adopted, but there are certainly many cases where it could, and the suggestion is respectfully made by an old workman for what it is worth.

If any valid objection is to be made to this system of working, on the men's side it will be in respect of the long intervals between meals. Men would have to breakfast about seven o'clock in the morning, when their appetites were not very good, wait till about 12 or 12.30 for lunch, and then not dine till about 6.30 at night. In reply to this possible objection it may be observed that the eight hours system might very likely mean still longer intervals between meals, besides the introduction of the three shift system and the continuance of the six days a week system.

Perhaps the five ten-hour days' system here suggested could be worked with two breaks of 15 minutes for snacks, or, by starting at 7 instead of 7.30, there might be two half-hour breaks for meals—one at nine o'clock and the other at 1.30.

Certainly a reform on some such lines, effected by mutual co-operation between employers and workmen to fit the various trades, would be preferable to any hard and fast scheme like an eight-hour day, and especially a legal eight-hour day. The demand for a general eight hours system is too rough and ready. It seeks to set both Nature and economics at defiance. Many trades are affected by the weather and the seasons, and an attempt to work uniform hours all the year round would be ridiculous. Again, there is far more fatigue in some industries than in others. If the porter at the little wayside station is to have an eight-hour day, we may soon have the blastfurnace-man demanding a four-hour day.

We have the curious spectacle just now of the labour leaders balloting the unions on the question of striking for a uniform eight-hour day for all trades, while tens of thousands of miners in the north of England are ready, and even anxious, to strike in order to be rid of the obnoxious three-shift system of working which has been introduced under the Mines Eight Hours Act.

There is deep discontent in the northern coalfields over this very question. It is with great difficulty that the leaders are keeping the men at work pending negotiations with the employers for some modification of the new system. The men did, in fact, strike for sixteen weeks against the system at the very beginning, in 1910. They were eventually persuaded to give it a trial. But experience has in no way lessened their resentment.

Under this three-shift system for the men—that is, three eight-hour shifts in each twenty-four hours—with a double shift for the boys, the men and boys are going out and coming in at almost all hours of the day and night. In households where there are two or three sons as well as father employed at the pits, and on the different and changing shifts, the women have hardly ever done preparing meals and changes of clothing. Evening leisure is lost. Domestic and social customs are upset. In some houses ten separate meals have to be prepared each day. The old short shifts at the week-ends have been abolished because the men's hours are limited on the midweek days. The boys cannot attend evening classes regularly like they did under the old system, because they are now often working until nine or ten at night. The men have still less time for gardening, sport and home life, because they have in many cases to work an extra day per week, and as that means Saturday it is very distasteful. Trade union, political and co-operative meetings have to be held on Sundays, because full attendances cannot be got at other times with some of the men at work through the nights. Even the public health authorities have noted an increase in the infantile death rate through the women having less time to attend their children.

In many trades an eight-hour working day would involve the introduction of the three-shift system, with its irregular and unnatural hours of sleep, work and meals, its serious interference with home and social life, and its curtailment of week-end leisure.

For reduced working hours in many industries there is now a good—an unanswerable—case which enlightened employers will not offer to challenge ; but the demand for a general, uniform eight-hour day is closely akin to madness.

# Current Topics

### Forthcoming Shipping Exhibition.

AN exhibition of shipping, engineering and machinery is to be held at Olympia, London, from September 25th–October 17th, 1914. An influential committee has been formed under the honorary presidency of Sir Owen Phillips, K.C.M.G., while the vice-presidents are the Marquis of Graham (director, W. Beardmore & Co., Ltd.), Sir Alexander B. W. Kennedy (past pres. Inst. C.E., past pres. Inst. M.E.), E. H. Tennyson D'Eyncourt, Esq. (director of Naval Construction to the Admiralty), and Col. R. Saxton White (joint general manager, Sir W. G. Armstrong, Whitworth & Co., Ltd.).

It is proposed in connection with this exhibition to devote the main body of the hall to naval and shipping exhibits, and also important exhibits of marine and general engineering appliances, working or otherwise.

The only two exhibitions of importance of this character which have been held in this country for the last thirty years are the Naval Architecture and Marine Engineering and Fisheries Exhibition at Tynemouth, September, 1881, and the Naval and Mercantile Marine Exhibition at Olympia, in 1910, and it is therefore considered that the time is ripe to hold a really representative and comprehensive exhibition of specialities connected with these great industries, particularly in view of the remarkable advances during recent years in all directions.

Among other interesting exhibits will be a wireless telegraphy apparatus working from end to end of the hall.

The London offices are situated at 104, High Holborn, W.C., where full particulars can be obtained.

### The Proposed Post Office Tube Railway.

A GOOD deal of interest is at present being evinced in public and political circles in the proposed scheme of tube railways for the London Post Office services. The proposal is to run an underground tube, nine feet in diameter, and containing two tracks, from the East to West of London, for the carriage of mails and parcels. The route followed is at present suggested as follows:—Paddington District Office (connected with Paddington Railway Station), Western Parcel Office in Bird Street, West Central District Office in New Oxford Street, Mount Pleasant Sorting Office, G.P.O., St. Martin's-le-Grand Office, Liverpool Street Station, and Eastern District Office in White-

chapel Road. The length of this line would be 6½ miles, and the approximate outlay is estimated at £1,000,000. Arrangements would be made for connecting up Euston, King's Cross, Cannon Street, London Bridge and Waterloo Stations, also the Northern and Southern District Post Offices, if this should be found desirable, at a later date. The trains in which the letters and parcels would be conveyed would be electrically operated and controlled from the stations, no drivers being employed on the trains. The prevention of accidents would be ensured by the use of electro-automatic safety controlling devices, the speed at which the trains would be run being about 25 miles per hour. The stations would be fully equipped with lifts, automatic conveyor systems, &c., for the rapid handling of the letters and goods. The benefits to be derived from the system appear to be of a high order of merit from many view-points, and it is to be hoped that the powers that be will see their way to enable it to be carried through.

### The Channel Tunnel.

THIS question has made its periodic reappearance, and its advocates consider the prospects appear brighter than at any time previously. Mr. Asquith recently received a deputation and while, perhaps naturally, maintaining a non-committal attitude, he did not evince any pre-determined opposition.

Besides an influential backing over here, the scheme is warmly supported in France, and M. Sartiaux, the chief engineer to the Northern of France, in an interview with a representative of the *Echo de Paris*, went so far as to express the opinion that in five years it would be an accomplished fact. Not only does he anticipate a large increase in passenger traffic, but considers commercial intercourse would benefit enormously. The cost of the tunnel which would have to be constructed about 350 ft. below the surface, would probably be somewhere near £16,000,000, and it is anticipated that a large portion of this would be subscribed in France. The *Temps* suggests that the tunnel should be divided into two sections, one being reserved for automobile traffic. This suggestion will probably add the support of motorists to the scheme.

Now that the conquest of the air has been practically achieved and the loss of our insularity is an accomplished fact, any sentimental objections on this score have disappeared, while the tunnel would undoubtedly offer a means of ingress for food supplies and possibly also, for military aid from France, in the unfortunate event of our having temporarily lost the command of the sea. That is, of course, assuming that our relations with France are on the same friendly footing as at present, but even if the reverse were the case, in view of the ease with which the tunnel could be flooded from either end, neither country need have any apprehensions on the score of possible invasion. It is indeed curious that such an objection should have ever borne any weight. The question really seems to resolve itself into this:—Will the enormous outlay of capital involved be justified by actual results?

### Aeroplane Construction.

THAT satisfactory progress in rendering aeroplanes more reliable and safe is being made is evidenced by the recent invention by Lt. Dunne, of an automatic self-righting device. The tests of this contrivance, carried out by the French Government, have apparently given very good results, and if all that is promised be achieved, a very important advance will have been made. Capt. Perron has also been investigating another device for the same purpose, consisting of two propellers partly enclosed in cylinders.

The adaption of the parachute for the safety of pilots, by M. Bonnet, also marks an advance in life-saving appliances. This was tested by M. Pégoud, who made a successful descent. Although he only dropped from a height of 200 yards, he stated that he could have come down with equal ease and comfort from 1,000 or 1,200 yards.

The parachute is composed in part of an air chamber inflated in a box under the seat of the pilot, and the aviator has only to push a lever to cause the parachute to spread out in five seconds. In another five seconds the aviator is carried automatically from his seat. The whole operation takes some ten seconds.

Doubtless the apparatus is capable of further improvement, and its operation of speeding up for a few seconds are of vital importance, but the idea certainly promises to be of great use in cases of sudden emergency.

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### The Panama Exhibition.

ALTHOUGH the British Government has decided against participating officially in the exhibition at San Francisco, there is every probability that British shipping companies will be represented—and, we hope adequately. This is important, since there is no doubt that the opening of the Canal will produce important developments in shipping circles. There is, too, a growing feeling that British business firms cannot afford to disregard the opportunities that the Exhibition will afford. The expansion of our South American trade will depend very largely upon the maintenance of our supremacy in shipping; it is therefore highly desirable that manufacturers and shipowners should co-operate to secure adequate representation for our interests.

In the same connection it is interesting to note that although the German Government has likewise determined not to participate, Herr Ballin, the chief of the Hamburg American Line, is energetically initiating a movement which is meeting with influential support, to ensure a proper representation of German interests, and to this end is offering special terms for the transport of exhibits. Thus it is all the more necessary for Great Britain not to lag behind.

British manufacturers, however, are fully justified in asking for exemption fr m tariff duties on their exhibits and we certainly think that the American authorities should meet them in the matter.

### Long Distance Electric Railways.

ELECTRICITY has, of course, already established its supremacy over steam traction, for comparatively short sections of railway on which a very frequent service is maintained. Mr. H. M. Hobart, however, in a paper recently read before the American Institute of Electrical Engineers, pursues the subject further and contends that even for long distances with a sparse traffic, electric traction will be found more economical. He takes, for the purpose of comparison, a typical express passenger service, for which it has generally been considered the steam locomotive is far away the most suitable, assuming that such a service includes non-stop runs of 100 miles in two hours. During such a run maximum speeds of over 60 miles an hour will be attained and the average tractive effort for a train of 10 Pullman coaches, weighing 750 tons, he takes at 9 lb. per ton. The total tractive resistance, including 1,670 lbs. for the locomotive, would thus be 8,420 lbs., and on the basis of an efficiency of 85 per cent. from cylinders to crank pins on a steam locomotive, the power required will be 1,320 I.H.P. On the basis of a consumption of 3.5 lbs. of coal per I.H.P., 9,240 lbs. of coal will be burnt.

But with an electric locomotive hauling the same train, the author estimates that the overall efficiency is from 6 to 6.5 per cent., and that the quantity of coal consumed at the generating station would amount to only 5,750 lbs. for the two-hour journey, being only 47 per cent. of the quantity required for the steam locomotive. In other words, the amount of coal is 122 lbs. and 58 lbs. per train mile for the steam and electric locomotives respectively.

The case of a non-stop express, the author points out, has been purposely taken, as it is on such runs that steam is supposed to show to the best advantage, but he states that had occasional stops been assumed, electric traction would have shown up even more favourably as regards low fuel consumption.

With regard to the source of power,

he is of opinion that, generally speaking, railway companies would do far better to purchase electricity from supply undertakings rather than generate their own.

Mr. Hobart certainly makes out a strong case for the system he advocates, of course, theory is often very different to actual practice, but it is practically certain that further developments on these lines may be expected on railways in the near future.

### The Variable "Horse-Power."

A BULLETIN issued by the United States Bureau of Standards late last year announced that the equivalent of 746 watts would in future be adopted by the bureau as the exact equivalent of the American and British unit "horse-power." The Am. Inst. E.E. adopted this value in 1911. The salient facts of this matter are that the horse-power is dependent, for its fine valuation, upon the altitude and latitude at which it may be measured in any particular instance. James Watt, in London, adopted the horse-power as the rate of work done, the latitude of London being approximately 50 degrees, and the level approximately sea-level. The A.I.E.E. therefore, defines a horse-power as the rate of work expressed by 550 foot-pounds per second at 50 degrees latitude and at sea-level. Unlike the horse-power, the watt is strictly definite, uninfluenced by altitude or latitude, being composed of factors representing time, length and mass, in their fundamentals. The recommendations of the A.I.E.E. and of the U.S. Bureau of Standards are undoubtedly good ones, and although the variations in the value of a horse-power at different latitudes and altitudes are slight and may appear insignificant for all work-a-day purposes, it can hardly be denied that preference should be shown to a term of definition which is independent of these factors. The British Institution of Electrical Engineers, therefore, might well signify their agreement to the move which has been made in the States.

## CORRESPONDENCE

*The Editor.*

SIR,—I have read with interest the article in the September number of your journal making comparison of some of the many forms of overhead construction used on different electric railways in the world.

There are one or two points, however, with which I cannot quite agree, and I beg to be allowed to express an opinion on the matter.

The author is apparently very much in favour of single catenary systems as compared with those of the double catenary type and draws attention to the faults of one line—the N.Y.N.H. and H.R.—to give weight to his argument. Now this is hardly fair as the construction of the N.Y.N.H. and H.R. has a number of faults which are acknowledged by responsible officials connected with that line. The author states that the equipment of the N.Y.N.H. and H.R. is an improvement of the *older* L.B. and S.C.R. construction. This I cannot agree with in the least. Firstly, I understand that the L.B. and S.C.R. construction was brought into use some time after that of the N.Y.N.H. and H.R., and, consequently, the latter cannot be an improvement on it; and, secondly, apart from this altogether, the two designs differ to such a great extent as to be almost incompatible.

In addition to dividing overhead construction into three main types, viz., plain supported, single catenary, and double catenary, the latter can be further sub-divided into classes which may be referred to as "rigid" and "flexible." The N.Y.N.H. and H.R. belongs to the former class, whilst the L.B. and S.C.R. construction belongs to the latter. No further proof of this is necessary than the fact that

the N.Y.N.H. and H.R. was unsatisfactory, and had to be altered, while that of the L.B. and S.C.R. is, on the contrary, so satisfactory as to warrant its extension.

With the original N.Y.N.H. and H. construction it was found there was extreme sparking at the collector due to rigidness, and, consequently, excessive wear. In the case of the L.B. and S.C.R. the sparking is negligible, and the wear extremely small, both on the trolley and aluminium collector strips. It is true that the collector strips on the N.Y.N.H. and H. are of steel, but if an aluminium strip were used it is doubtful if it would last more than a day or two, and sparking would be found anyhow.

The rigidity of the N.Y.N.H. and H. construction in the vertical plain is, of course, due to the employment of solid droppers regardless of their length and also to the use of rods tying the catenary wires to gether at each point where the droppers are fixed. In the case of the L.B. and S.C.R. construction the droppers are, when above a certain length, made of two rods looped together, thus giving vertical flexibility, while rods tying the catenary wires are only used at two or three points in a span. A pressure of about fourteen pounds is sufficient to bring about an appreciable lift in the trolley, but to move the trolley in a horizontal direction a distance of at most two inches, requires almost herculean strength on the part of any one standing on the roof of a train, for the reason that a horizontal pull is almost directly against the catenary wire on the opposite side of the trolley.

Another fault with the N.Y.N.H. and H. construction is the great weight of the Y-shaped piece directly above the trolley clip into which the droppers are fitted, compared with that of the trolley itself, resulting in knocking of the collector when passing, and consequent kinking of the trolley. In the case of the L.B. and S.C.R. construction the weight above the trolley at each clip is so small that there is *absolutely no knock whatever* on a bow passing, the trolley lifting uniformly at all points under the upward pressure. I have watched on many dozens of occasions, but have never yet seen a case of jumping.

A further point in favour of the L.B. and S.C.R. construction is that each catenary span is separately adjusted and erected, thus any required sag can be obtained or altered.

Further, a type of pull off is used on the L.B. and S.C.R., which neither requires additional insulators nor pull off poles as in the case of the N.Y.N.H. and H. The rods forming these are fixed to the catenary wires at the latter's point of suspension, and the arm clipped to the trolley itself is hinged at the apex of the triangle formed by these rods, thus maintaining the free vertical movement of the trolley. This will be readily seen from Fig. 7 of the article in the September issue.

I think the foregoing is sufficient to prove the absolute superiority of the L.B. and S.R. construction as compared with the N.Y.N.H. and H.R. The faults of the latter, however, have been somewhat, though not completely compensated by the employment of a further wire supported from the original trolley at points midway between the droppers.

The single catenary is excellent for cheapness, but the horizontal play is obviously excessive and pull offs using no extra insulators cannot very well be used—unless the catenary wire is doubled at the points of suspension—both being questions the importance of which cannot be over-estimated. As regards difficulty of drivers seeing signals with the double catenary construction I fail to see how one extra catenary wire for each road can make much difference to the outlook from driving cab.

Apologising for taking up so much of your valuable space, which I suggest is somewhat compensated by the importance of the subject discussed.—Yours truly,

BERNARD DE NEVERS.

Crofton Park, S.E.

## Book News

**The Principles of Setting-Out, Securing and Tooling Operations.**

By Alfred Parr, published by Longmans, Green and Co., London, price 7s. 6d. net.

We take up with pleasure the latest work of Mr. Parr, which has interested us greatly, both with its novel arrangement, as there are no chapters to subdivide the book, and with the material in its pages. There is no doubt that Mr. Parr, as an instructor in workshop practice, has felt the need of such a book of instruction for his students and owing to the lack of reliable literature on the subject has tackled the situation. The result of his labours is highly creditable, and will be welcomed by many of the teachers of this subject. It is a most practical and serviceable work.

The " apology " for its production is perhaps best given by Prof. Bulleid in his introduction, who states that " the ever-increasing variety of engineering work, and the degree to which specialization is carried in modern manufacturing processes, renders it more and more difficult for a workman to obtain a full knowledge of his trade, and to no branch of work does this apply more than to setting-out. A man trained in a typewriter factory may acquire a sound knowledge of jig and templet work, and die making, but have very little experience of dealing with castings and forgings of any size on a marking-off table, whereas, a man working in a general repair shop has plenty of work of the letter kind and very little of the former. Moreover, there is an increasing tendency for setting-out to become a separate department, the man who machines an article working to instructions from the tool room or gauge department. At one time setting-out meant covering a casting or forging with whitewash and drawing in the lines with a scribing block on a table; now it involves, in addition, the use of special fixtures for holding work on the machines, jigs for drilling through, and templets and gauges for setting the tools and testing the accuracy of the work, many articles being finished without a single line being drawn on them."

We think, however, a more appropriate and comprehensive title would have been " Modern Workshop Practice," because this is what the book is full of. The author describes in clear and simple language all the various tools and instruments of precision necessary for the complete marking-off of all kinds of work. These instruments are shown at the beginning for the general student, but for the more advanced student the use of the same instruments is frequently seen in testing the accuracy of pieces of work throughout the book.

Limit gauges, of course, find a place, and a description is given of the latest system of gauges, the Johansson, which comprises a series of flat steel plates of varying thicknesses, so that by using a combination of these plates any size can be obtained from 0.1001 to 8 or 10 in. Some useful notes are given on the design and construction of jigs, and we note that the author rightly considers that the jig designer must be a specialist, not necessarily a first-rank draughtsman, but a man who has passed through the various stages of tool room work, and thus able to make a happy combination of accuracy and utility in his designing with a view to simplicity and ease in handling the jigs when made.

In " hints on marking-off " occurs a paragraph of vital importance: " In the first place, the casting or forging should be overhauled to ascertain whether the job will clean up all over before commencing to line out any part whatsoever." This point cannot be too strongly impressed on the budding machinic, because instances occur daily of machine work being put on jobs which are too small perhaps in some odd place to finish to the requisite

dimensions, and time, money and patience lost thereby.

A book of this nature would not be complete without some reference to gearing; and the author has treated this in a simple and concise form, giving the involute tooth the preference, as the one in general use, to the absolute exclusion of the cycloidal form. The generating of gear teeth is exemplified as carried out by the Fellows Gear Shaper. We have, however, one very serious complaint to make, and that is, that while grinding and grinding machines naturally have a place, only seven pages are devoted to the subject, a totally inadequate number considering the vast strides made during the past few years in this method of machining, and its correspondingly growing importance. The author states that "grinding machines are essentially in use where precise methods of working are adopted or interchangeable parts are manufactured." This is true, but he does not go far enough and only one machine is illustrated, the universal, no mention whatever being made of the modern plain grinding machine which has become a necessary addition to every kind of machine shot, and is essentially a manufacturing machine.

The book concludes with some notes on the "City and Guilds of London Institute" examination questions which will prove beneficial to those who may be entering for those examinations.

### Coast Erosion and Protection.

By E. R. Matthews. Charles Griffin and Co., Ltd., London, 1913. 10s. 6d. net.

The statement in the report of the recent Royal Commission upon this subject that "sea defence is not a national service" is much to be regretted, not only because there is a very strong body of contrary opinion, but because such a statement rather tends to minimise, in the eyes of the general body of the interested public, the urgent importance of the matter. The volume before us is useful as combating this danger; it is written in no alarmist spirit, but sets forth scientifically the actual facts and the extensive nature of erosion at certain points of our coast. Even if accretion equalled erosion the matter would still be sufficiently serious, but the author states that such is not the case and that erosion predominates. Mr. Matthews is the borough engineer of Bridlington, and in this capacity has had much practical experience. He has, moreover, made the matter a special study and is consulting engineer *re* coast erosion to several local authorities. The work, as might be expected, is eminently practical. The whole subject is comprehensively covered and the various methods of coast protection are fully described and their efficiency contrasted. A chapter dealing with the author's own experiments on the effect of sea water on cement and concrete is included and is of great interest for, of course, it has a very important bearing upon the question. The difficulties of constructing effective coast defence works are many, and successful results can only be achieved by research and experience. When it is realised that the impact of a wave frequently reaches three tons per square foot, the terrific forces that have to be resisted will more easily be understood. The illustrations and photographs are exceptionally good and the large clear type in which the book is printed is a welcome relief from the small close type of so many technical publications.

### Turbines Applied to Marine Propulsion.

By Stanley J. Read. Constable and Co., Ltd., London, 1913. 16s. net.

This volume embodies a special course of lectures delivered by the author at the Naval Architecture Department of the University of Glasgow in the early part of 1912, but contains additional matter. As the book is intended more especially for practical use, thermo-dynamics and mathematics are dealt with as little as possible, but the absolute essentials are given in the first chapter. After discussing nozzles and blade forms, and the question of general design, the various types are severally described. Superheat and transmission each claim a separate chapter and the volume concludes with a useful section of general notes. We should like to have

seen some reference to gas turbines but the author is of opinion that they are in too experimental a stage for practical use ; there are, of course, those who will dispute this. The illustrations are good and clear, and the volume is a useful addition to literature on the subject, but progress in turbine construction is still being made so rapidly that a book of this sort will soon grow out of date unless frequently revised.

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**The Control of Water as Applied to Irrigation, Power and Town Water Supply Purposes.**

By Philip A. Morley Parker, A.M.I.C.E., &c. Geo. Routledge & Sons, Ltd. 21s. net.

This work is to be regarded as an advanced manual for civil engineers in active work, and will prove useful to technically trained men. The amount of initial knowledge assumed in the reader is considerable, and the work cannot therefore be looked upon as suited for the junior engineering student. The author exhibits a passion for figures, tables, and formulæ, and these appear in abundance on almost every page of the book. Although the treatment of the theoretical parts is intentionally cursory, the formulæ are based largely upon well-conducted observations, and are believed, on that account, to possess greater practical utility. The contents of the volume amply cover the wide range of subjects indicated by its title, and, after the customary "preliminary data" and general theory of hydraulics, treats in turn—the gauging of streams, discharge of orifices, collection of water and flood discharge, dams and reservoirs, pipes and open channels, the purification of water and other matters connected with town water supplies, irrigation, moveable dams, and hydraulic machinery, including turbines and centrifugal pumps. The volume will also be found a valuable record of much practical experience based on the author's own "notes," gathered over a period of some 18 years of professional work. The space at our disposal will not admit of reference to the many excellent features of this remarkable book, but it may be said that the whole work is a model of painstaking industry of an unusually high order of merit, and embodies in its 1,055 pages of closely printed text a vast mass of information, both theoretical and practical, the like of which is not to be found in any existing work. Its many interesting notes of a thoroughly practical character will be read with interest by the executive engineer, such, for example, as on the "coating" and durability of cast iron pipes, the filtration of water, water dams, culverts, trench work, and a host of other matters. We observe, however, in connection with the dipping of cast-iron pipes in the application of Angus Smith's and other like coatings, no mention appears to be made of the modern approved method of a preliminary "dip" into hot *water* for the cleansing of castings before immersion in the bituminous liquid, which, in our experience, is very desirable where a good permanent coating is essential. Another point to which we must take exception is the rather too sweeping generalisation on page 573 in regard to "mechanical filters" which are stated to be "more expensive to maintain and to supervise than the slow-sand type." This is by no means always the case. Many illustrations of mechanical filters within our own knowledge, are found to be decidedly cheaper to maintain and simpler to supervise than the slow sand type. Neither is it by any means the fact, in this country at any rate, that "the effluent from a mechanical filter is usually considered to be satisfactory when it is free from *turbidity*," as stated on page 575. On the contrary, a high degree of bacteriological purity is now demanded and obtained from the suitably designed mechanical filters which must be capable of taking out all water bourne germs like the bacillus coli and the typhoid bacillus. But these are matters of recent practice which perhaps have not fallen so fully within the author's experience as have the many other topics so ably dealt with in this comprehensive and well arranged work, which will, we anticipate, speedily find its way into the offices of most practising water en-

gineers, and thus come to be looked upon as a useful standard work of reference.

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**Der Torsions-Indikator (The Torque-Indicator) Pt I : Die Elektrischen Methoden zur Verdrehungsmessung.**

By Dr. Ing. Paul Nettmann, 78 pp., 34 ill. M. Krayn, Berlin, 1913.

The great difficulties of determining the output of very large engines, more especially marine-engines, many years ago led to the design of the first torque-indicators. Quite recently the coming forward of large Diesel engines for marine purposes has caused a great activity in the designing of suitable indicators for measuring large outputs. There are three different types of torque indicators :—The electrical, mechanical and optical. In the work under review the author deals exhaustively with the electrical, and promises two more treatises dealing with the other methods. The work is largely descriptive, *i.e.*, the most important types already existing are described rather fully, besides such apparatus, which, though patented, has not actually been constructed. The work is very useful as containing a clear exposition of the guiding principles of electrical torque-indicators, but it is unfortunate that no results of actual tests are given.

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**"Oil."**

By W. Antrobus. John Heywood, Ltd., Manchester. 1913. 3s. 6d.

The keynote of this little book is the possibility of cheapening oil by producing it from raw materials hitherto regarded as practically valueless. The question has, of course, been prominently brought to the fore by the rapid rises in the cost of oil and petrol, and the possibility of the exhaustion of existing means of supply. The author touches also on electric propulsion, and advocates the extensive use of water power for generating current, to be used in connection with Edison's new storage battery. The book should prove of great interest to motorists, and all others interested in this matter, and is excellently illustrated by photographs specially prepared for the "Oil Power" number of Cassier's Engineering Monthly, and reproduced by permission of the proprietors.

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**The Fitting and Erecting of Engines.**

By C. Leslie Browne. Emmott & Co., Ltd., Manchester, 1913. 3s. 6d.

The author wisely emphasises in the preface to this little volume that book work can *not* form a satisfactory substitute for practical experience, and the information herein contained is intended to supplement the workshop practice of young engineers. The contents originally appeared as a series of articles in the *Mechanical World*, but have, of course, been revised and brought fully up-to-date. It is written in a simple, yet eminently practical manner accompanied by numerous diagrams, and should certainly prove of value to students.

## SHIPBUILDING AND MANUFACTURING NEWS

**A Sea Going Motor Cruiser.**

THE below is a photograph of the motor cruiser, *Maiko*, recently completed by John I. Thornycroft and Co., Ltd., for a customer in France. She is 55 feet in length with a beam of 10½ feet and a draft of 3½ feet. Her motors are of the Thornycroft C 6 type developing 70 B.H.P. on paraffin. A mast hinged in tabernacle with lug and head sails is fitted. She has just arrived at Cape Finistere under her own power, and the owner reports that she is giving every satisfaction.

Another seagoing vessel lately constructed by the same firm is the *Advice*, which won the London to Cowes race, a distance of 176 sea miles, which was covered in 17 hours. This cruiser is 43½ ft. over all, and has a 6-cylinder engine developing 53 B.H.P. at about 1,000 R.P.M., but during the

SEA GOING MOTOR CRUISER "MAIKO," BUILT BY JOHN I. THORNYCROFT & CO., LTD.

race the power developed was not more than 30 B.H.P., owing to the special valve reducing arrangements necessary in order to comply with the rules. Under these circumstances, therefore, the speed of 10 knots maintained for the whole journey was exceptionally good, and reflects great credit on Messrs. Thornycroft.

### Influence of Racing in Motor Boat Design.

THE accompanying photograph serves to illustrate the influence that racing has upon the design of non-racing boats. It is of a boat just shipped to Viborg by Messrs. J. W. Brooke and Co., Ltd., of Lowestoft, and illustrates a type of which they are building several for general utility purposes. The engine is the firm's 4-cylinder high-speed type running at 2,100 R.P.M. direct on to the propeller, capable of developing a speed of 23 knots. The boat itself is 21 feet long with a beam of 4½, and has a

MOTOR BOAT BUILT BY MESSRS. J. W. BROOKE & CO., LTD. LOWESTOFT FOR A CUSTOMER IN VIBORG. VIEW TAKEN FROM ABOVE.

carrying capacity of four people. Such a boat would prove eminently suitable for work on many of the waterways in the colonies, and the reliability of Messrs. Brookes' engines is well known.

This firm has recently completed also a 35 ft. steel motor tug for the Sudanese Government, for use at Khartoum. The four-cylinder engine develops 45 H.P., and the steering is arranged forward. Reversing is effected by a special Brooke single lever epicyclic gear of heavy pattern. With a displacement of 3½ tons, this boat averaged a speed of nine knots on trial.

### Internal Combustion Locomotive Engines.

THE internal combustion engine once established has soon found its way into fields of usefulness beyond the mere passenger vehicle or pleasure boat. Fishing smacks, lifeboats and big steamers already own it as their motive power, and locomotives by no means of necessity of small size are equipped with it by the Gasmotoren-Fabrik Deutz of Cologne, such locomotives using as their fuel, petrol, heavy gasoline, benzol, crude benzol, paraffin and alcohol.

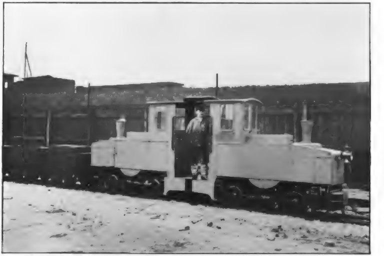
All manner of light railways have failed or been but a half success for lack of a good motive power. A small steam locomotive does not show up well in its capacity as a narrow gauge haulage power. In mining work particularly the need of a good small locomotive has been felt, for the electric locomotive with its internal power circuit is often quite unfitted for the situations in which it finds itself, and it was to mining enquiries that the internal combustion locomotive owed its being. The engine is self-contained and independent of any power station, its first cost is less, there are no losses of time by accumulator charging, and cost of upkeep is small. These advantages apply to the comparisons with both electricity and compressed air, which latter type is saddled with a bulky reservoir.

The "Otto" engines are constructed by the Gasmotoren Fabrik Deutz and are built up of three main parts, the underframe, the engine and the driving

12 H.P. OTTO INTERNAL COMBUSTION MINING LOCOMOTIVES AT WORK IN THE LAURWEG MINE NEAR KOHLSCHEID.

gear. The frame is carried on two driving axles, the two pairs of wheels being coupled by chains round gear wheels on the axles, next to the running wheels. The engine is of single cylinder horizontal type with a good fly wheel, and gearing to give two speeds in either direction with a chain drive to the main axle and a coupling chain as stated above or coupling rods of the old type to the other axle. The speed changes are effected by coil friction clutches worked by the driver. A hand lever determines the direction of travel; the wheel, by its extreme left and right and its middle position determines the two speeds and the rest position. The cooling tank of

50 H.P. MAIN LINE GAUGE LOCOMOTIVE SHUNTING ROUND WORKS BUILT BY THE GASMOTOREN FABRIK DEUTZ



36 H.P. DUPLEX LOCOMOTIVE FOR 75 M. GAUGE, WORKING ON PORTABLE TRACK OF A FOREIGN GOVERNMENT.

the engine forms a part of the engine bed plate and water circulates by the differential gravity of the heated water. Ignition is by low tension magneto. The mechanism is wholly enclosed from dirt and dust. Eight standard types are made by the firm with engines varying from 6 up to 60 H.P., the weight from 63 to 344 cwts., and the haulage pull from 340 up to 6,270 pounds as a maximum in the largest size. In mine or field work the gauge varies from 16 to 28 inches, but shunting and tramway locomotives are made for the 4'8½ in. gauge, the former varying from 12 to 50 H.P.; the latter from 15 to 60 H.P.

These locomotives throw no sparks and, therefore, are very safe for forest work or dry grass countries as well as in factories where inflammable material is being worked, as paper mills or cable works.

The total working costs per ton mile for the 16, 12 and 8 H.P. sizes has been given by users as 1·3, 1·0, and 0·8 pence, including 12% for depreciation, 5% per interest, and 4% for upkeep and, of course, labour, fuel, oil and stores.

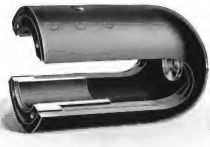
When a locomotive is required for a light rail it is made duplex and may have in all twelve wheels in two units of six coupled wheels each. Such an engine is shown in one of the accompanying illustrations.

In addition to petrol and alcohol another fuel of great importance is that product of coal tar distillation known as benzol. There are perhaps 7 or 8 benzol plants already erected in this country in connection with coke oven plants and, owing to the high price of petrol, this fuel is receiving great attention by motor-car owners. In Germany the majority of these locomotives are working on this fuel and about 12-15% increased output is obtained from the same engine as compared with petrol. This is due to the increased compression possible with benzol, viz., a pressure of about 130 to 145 lb.

Messrs. W. Silvesteen and Co., of 147, Cannon Street, London, are the agents for the "Otto" locomotives, both for Great Britain and the Colonies, and will be pleased to supply full information respecting them.

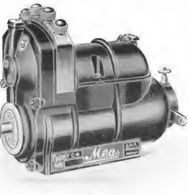
### The Mea Magneto.

A NEW type of Magneto has recently been placed on the market, which possesses some entirely new features.



THE BELL SHAPED MAGNET OF THE MEA MAGNETO.

In place of the universal horse-shoe type, the Mea magnet is bell-shaped, and placed horizontally and in the same axis as the armature. This magnet is mounted in an outer case, so that the movement of the contact breaker to the advanced or retarded position also rotates the magnet. Thus, if the relative position of armature and magnet is once adjusted so as to give the best spark, it follows that with the above arrangement this relative position always remains the same, and hence, whether advanced or retarded,




EXTERIOR VIEW OF MEA MAGNETO.

the spark is always of maximum strength. It is on account of this feature, that the Mea Company claims that easy starting up, without risk of back fires, is assured. Moreover, the certainty of firing at all speeds gives improved acceleration.

Other features of the Mea which deserve attention are the special high tension terminals, which ensure a positive connection, and prevent access of moisture; the entirely closed construction of the machine, so that it is waterproof and dustproof; and the ease with which the adjustments and inspection can be made. The Mea is extremely simple, and should therefore run for lengthy periods without trouble developing.

### Simplex Extincteurs.

AMONGST the various appliances manufactured by Messrs. Mather and Platt, Ltd., for the prevention or extinguishing of fires are the "Simplex" extinguishers. These appliances ar easily portable. Constructed of steel or copper, they throw, by chemical force, an effervescing fluid of great extinguishing power to a distance of from 50 to 60 feet.

Messrs. Mather and Platt, Ltd., have recently received a letter from the Portholme Aerodrome, Ltd., which bears remarkable testimony to the efficiency of these appliances for the purpose for which they are constructed. In the early part of the present year the Portholme Aerodrome, Ltd., purchased six "Simplex" Extinguishers. On June 29th an aviator flying at the Shoreham Aerodrome had a mishap whilst in the air, and the landing was so rough that the machine was smashed up. The petrol tank burst, and the machine was set on fire. One of the attendants at the Aerodrome hurried to the scene of the accident with one of Mather and Platt's "Simplex" extinguishers. With this he managed in a few seconds to extinguish the fire that was blazing furiously round the aviator. Unfortunately the aviator was already seriously burned, and subsequently succumbed to his injuries, but the Portholme Aerodrome, Ltd., in their

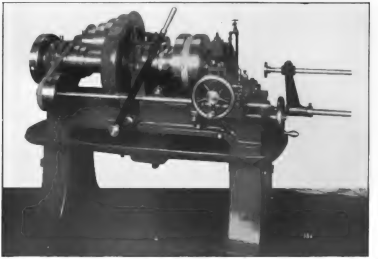
letter to Messrs. Mather and Platt state their belief that if their attendant had been nearer the scene of the accident in the first instance the life of the unfortunate aviator would certainly have been saved.

### New High-Speed Tube Cutter.

THE accompanying photograph illustrates a patent tube cutting machine manufactured by Joshua Heap and Co., Ltd. These machines are made in 2 in., 3 in., 4 in., and 6 in. sizes, and have been specially designed for cutting tubes in the most expeditious manner. The actual time taken to cut a 2 in. tube is only 7 seconds, while 15 seconds suffice for a 3 in. tube on the 3 in. machine. No time is lost in stopping and restarting the machine, instant gripping or release being effected by means of a patent gripping chuck fitted on the spindle nose operated by a single movement of the lever on the front of the machine. The cutting off rest is fitted on the saddle and has one tool only. The cut or feed is put on automatically, three rates being available, and an adjustable automatic stop motion is provided so that when the tool has traversed the required distance the feed is knocked off automatically. A finger-tip motion is also provided so that the feed can be instantly knocked off by hand. All the operating gear on the saddle is entirely enclosed so that cuttings cannot get into the working parts. An adjustable gauge, which can be quickly set for different lengths, is supplied, and also an automatic pump.

### Change of Name.

WE are informed that in order to obviate confusion which has frequently arisen between the name of Kelvin and James White, Ltd., and another firm of nautical instrument makers, the company has by a special resolution altered the style to Kelvin, Bottomley & Baird, Ltd., and it is requested that all communications be addressed accordingly. The address remains as before, 18, Cambridge Street, Glasgow.



HIGH SPEED TUBE CUTTER MANUFACTURED BY JOSHUA HEAP & CO., LTD, ASHTON-UNDER-LYNE.

### New Works.

MESSRS. THERMIT, LIMITED, have removed to larger and more convenient works at 675, Commercial Road, London, E., to which address all goods should in future be sent. All communications should be addressed to 27, Martin's Lane, Cannon Street, E.C., as before. Their telephone number has also been altered, and is now 4292, City (2 lines).

## NEW CATALOGUES.

### Aerial Conveyors.

From Bleicherts Aerial Transporters, Ltd., of 36, Old Broad Street, London, E.C., we have received an interesting booklet descriptive of the many uses to which their conveyors are adapted. It is illustrated with excellent photographs showing the plant at work under various conditions. Railway shipping, mining, passenger, and very many other applications are dealt with. The range of utility is a very wide one, and all interested should write for a copy of this book.

### Pressure Gauges.

Messrs. Fournier et Cie have sent us details of their thermo and pressure instruments. The Fournier system is patented in England and abroad, and it is claimed has solved the problem of centralizing to a single spot any distance from the place of action the reading, recording, and regulating of the actually existing degrees of temperature, humidity, ventilation, pressure, etc. Full particulars are given in the booklets issued by the Thermo and Pressure Instruments, Ltd., of 60, Salisbury Road, Kilburn, the sole British agents, who will be glad to answer all enquiries.

### Steel Forgings.

In the list recently sent us by the Rotherham Forge and Rolling Mills Co., Ltd., of Rotherham, not only are excellent photographs of various castings produced by the firm, but also some interesting views of the magnificently equipped machine shops and rolling mills, and a bird's eye view of the whole works conveniently situated on the river Don, with direct railway communication by private sidings. Steel forgings up to 15 tons in weight, and subject to standard tests, are undertaken by this firm, who are contractors to the Admiralty and other Government departments, as well as to foreign governments and railways. The 30-ton Buckton testing machine (a feature of the testing room) has been accepted by the B.O.T. It should be added that special attention is given to "Breakdown" orders.

Sir Boverton Redwood is the greatest British authority on petroleum. To give in the space of a few lines any adequate description of the many services that he has rendered in this connection is quite impossible, for he has made the subject a life study. Born in 1846, he is the eldest son of Dr. Theophilus Redwood, of Boverton, Glamorgan, who for over 40 years was professor of chemistry to the Pharmaceutical Society. Sir Boverton was educated at University College School, and studied chemistry under his father, becoming professionally associated with the petroleum industry as early as 1870. In 1872 he gave evidence for the first time before a Parliamentary Committee. Since then, of course, he has appeared before innumerable committees and commissions, has written many articles on petroleum and kindred subjects, and is the author of a standard work, a treatise on petroleum and its products, in three volumes, which is now in the third edition. In 1892 he visited Egypt in connection with the transport of petroleum through the Suez Canal, and made a joint report with Sir Frederick Abel on the subject. He is Adviser on Petroleum to the Home Office, the Admiralty, the India Office, and to the Corporation of London, Consulting Adviser to the Colonial Office, as well as to the Port of London Authority and the Thames Conservancy, and is a member of the Royal Commission on Fuel and Engines, now sitting under the chairmanship of Lord Fisher. He was knighted in 1905, and received a baronetcy on the occasion of the King's Coronation in 1911.

*Lavatelle.*

SIR BOVERTON REDWOOD, BART., D.Sc., F.R.S.E.

See reverse side.

CASSIER'S ENGINEERING MONTHLY

INCORPORATING CASSIER'S MAGAZINE

VOL. XLIV NOVEMBER, 1913. NO. 5

# THE CONSTRUCTION OF STEAM TURBINES

A REVIEW OF PRESENT PRACTICE

PART I.

By B. Schapira

IT is particularly during the past ten years that the steam turbine has developed to an almost unique degree.

The superiority of the steam turbine over the reciprocating-engine is due to the more complete utilisation of the expansion of the steam (Fig. 1), which permits of an economical utilisation of steam of an atmospheric pressure, a reduction in the costs of erecting, maintaining and lubricating the plant, and in the extreme simplicity and the small amount of space required by the turbine. Owing to the low speed of its piston an expansion of a degree equal to that of the turbine is not possible in the case of the reciprocating engine. Low pressure steam requires cylinders of such a large size that these would spend more work in overcoming the friction at a certain limit, which may be assumed to exist at a vacuum of from 85 to 88 per cent., than the energy, which may theoretically be disposed of and which is due to an increase in the expansion, would amount to.

Very frequently it becomes a question as to what degree of vacuum is the most economical. The air-pumps at present in use are so perfect in their way that the possibility is given of obtaining an extremely high vacuum. In order to improve the vacuum, the volume of the cooling water must be increased, *i.e.*, if the cooling water is drawn from a cooling-tower, the latter must be enlarged. The costs, as well as the amount of water required by the circulating-pump and the air-pump are increased, also the costs of erecting the cooling-tower. On the other hand again, the output, as also the efficiency of the turbine, are improved by an increase in the vacuum. The most economical vacuum will therefore be found at that stage where it becomes noticeable that any further increase in the costs of erection exceeds the profit resulting in an improvement of the energy. Fig. 2 illustrates the curves of the vacuum to be obtained at the inlet of the condenser in dependence of the quantity of cooling-water and its temperature.

The arrangement of the rows of blades may be effected in two essentially different ways. Either the rims of the moving-blades are fitted into the circumference of a drum (Fig. 3), or the rows of blades are lodged into single sets of wheels which are separated from each other by diaphragms (Fig. 4). Each wheel accordingly rotates within a

chamber separated from the remaining parts of the machine by the diaphragms. The first arrangement is what is known as the Parsons' drum type; the latter is the principle of the impulse-turbine. The construction of the drum-turbines is simpler and cheaper than that of disc-turbines; still the former do not advantageously adapt themselves to the high pressure field of the steam, for which reason they are combined with impulse-turbines and are built as combination disc and drum turbines.

consequence of the high rate of speed, in particular in the case of the Curtis wheels. The drawback with respect to the reaction-turbines is a loss of steam between the single rows of blades. As each single row of blades merely consumes a slight portion of the total drop of pressure, a large number of rows of blades is required; the bearings move apart, and the engine length increases considerably. Seeing that the specific volume of steam in the high-pressure part is slight, the length

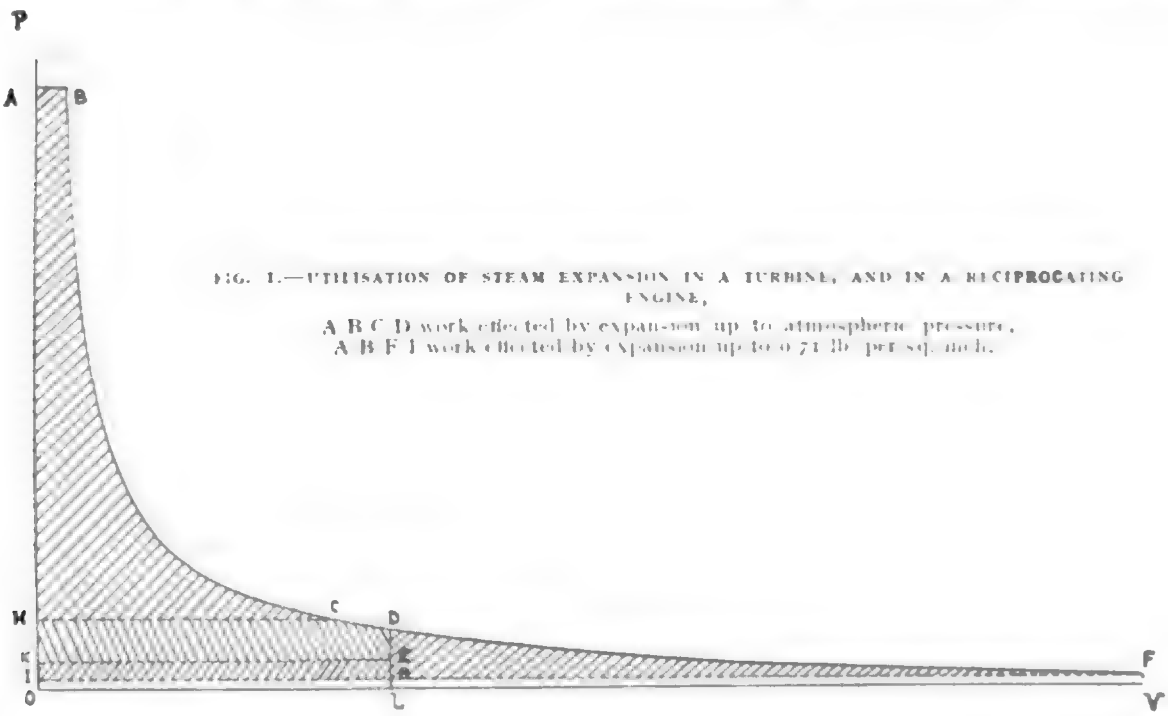



FIG. 1.—UTILISATION OF STEAM EXPANSION IN A TURBINE, AND IN A RECIPROCATING ENGINE,

A B C D work effected by expansion up to atmospheric pressure,
A B F I work effected by expansion up to 0.71 lb. per sq. inch.

Both the simple impulse turbine as well as the simple reaction-turbine have their disadvantages, which have led to their combination. In the case of the pure impulse-turbine, considerable leakages arise between the single stages by reason of the large differences in the pressure between them. For the purpose of packing up the single stages in an improved manner, a small diameter is chosen for the shaft in consequence of which a greater deflection of the shaft takes place. Through the clearance thus formed larger quantities of steam flow. A further part of the energy is lost in consequence of the steam-friction at the moving wheels by the high rate of speed, owing to steam shock and the formation of eddies. Beyond this the blades are subjected to a considerable wear in

of the blades must be made very small, in consequence of which the proportion of the area of the clearance to size of the blades becomes an unfavourable one, *i.e.*, the leakage increases. To reduce this loss a low peripheral velocity of the blades is chosen for the high-pressure part; beyond this, blades of a considerable le gth are made use of in order to improve the relation of the size of the blades to the area of the clearance, in consequence of which, however, the number of rows of blades and simultaneously, the engine length are caused to increase. At the same time the diameters of the drums at the high pressure side are made as small as possible. A clearance which is too small is again followed by the disadvantage, from the point of view of the safety of working, that owing to the

varying expansion of the different parts of the turbine casing and the rotor, these being made of various kinds of material, a touching of the blade-rims against the casing is possible and the blades may be damaged. It follows that a middle way between the increase in the size of the gap and the economy of the steam must be chosen.

friction, as also in consequence of shocks and eddies at the inlet and outlet edge of the blades, is lessened. Although the number of parts where losses occur in the case of Parsons' turbines is very large, the distribution of the losses into numerous stages favourably influences the efficiency; the losses due to friction and tension of a preceding stage

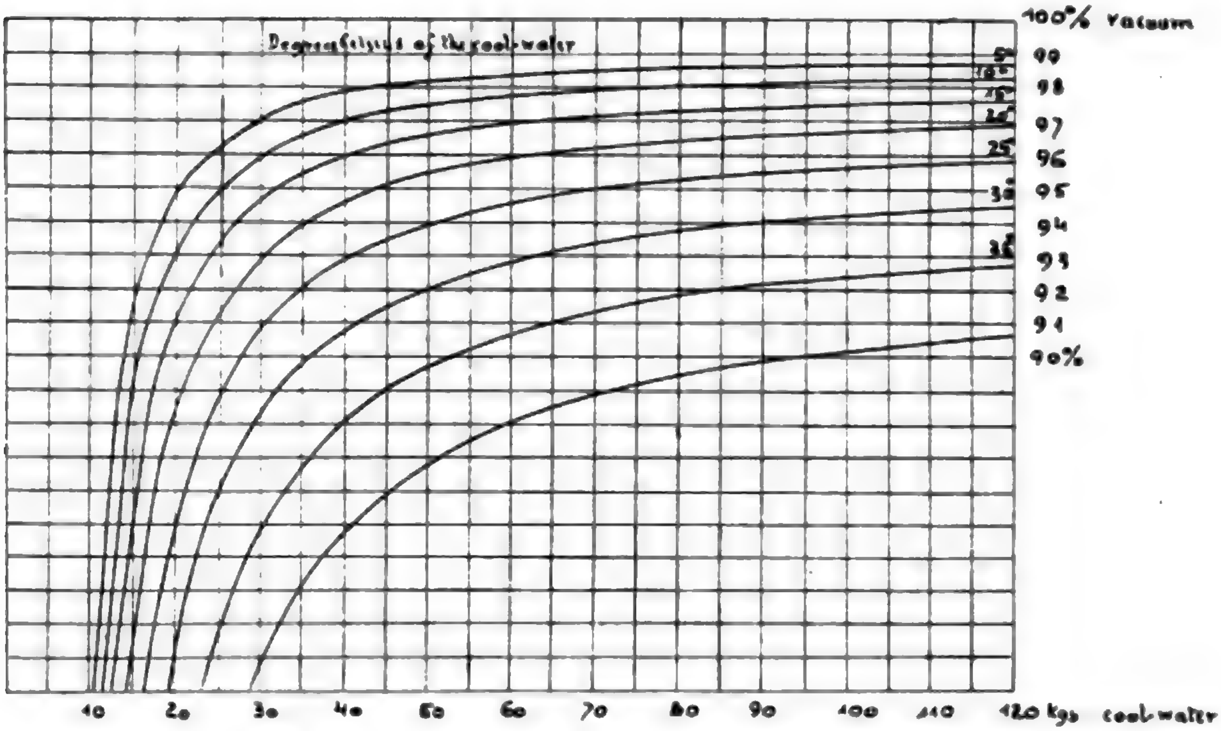



FIG. 2.—VACUUM TO BE OBTAINED AT THE INLET BRANCH OF THE CONDENSER IN DEPENDENCE ON THE QUANTITY OF COOLING WATER AND ITS TEMPERATURE.

In the reaction-turbine the moving wheels are subjected to a full admission, so that only a small diameter is required for the wheels in the high-pressure part. The consequence of this is that the peripheral velocity of the blades and, at the same time, the drop of heat or pressure utilised by each row of blades is reduced.

One of the advantages of the re-action turbine is the extreme simplicity of the construction, consisting only of a solid drum, into which the blades are fixed. The high thermic efficiency of the Parsons' turbine is to be traced to a sub-division of the drop of heat and pressure into numerous stages. The expansion is distributed evenly on to the guiding and moving parts and the flow of steam is ring-shaped and closed. By these means the losses due to steam-

adhere to the steam in the shape of heat and take part in the working-process of the succeeding stage.

The use of blades of the re-action type is of advantage as long as the length of the blade as well as the strength of the ring-shaped jet of steam, which is characteristic of the re-action turbine, does not fall below a certain point. In the case of blades of too short a length, the efficiency is influenced to an unfavourable degree, and that both in consequence of leakage as also because the disturbing influence of the walls and the ends of the blades on the edges of the ring-shaped flow of steam make themselves felt to a larger degree than in the case of high blades and a proportionately thick flow of steam. It follows that the smaller the volume of the steam flowing through

the turbine within a given period of time, the smaller has the diameter of the drum to be. It is thus that the number of stages required to utilise the total drop of heat is increased.

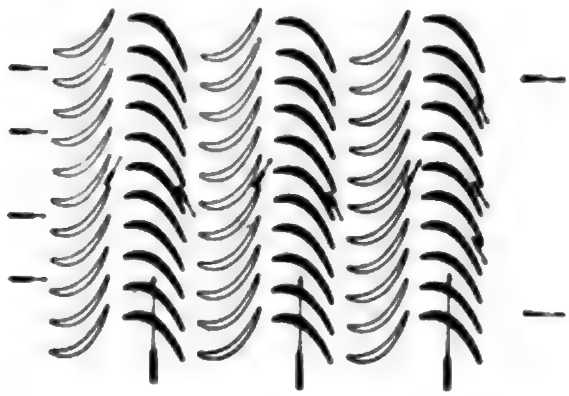


FIG. 3.—TURBINE ELEMENT ON THE RE-ACTION PRINCIPLE.

As soon as the required number of stages increases to such an extent that the apparatus required for this purpose is in no proportion to the profit obtained, an impulse wheel is connected in front of the blades of the re-action type, which preferably consists of a number of rows of buckets. This type of construction is being adopted at present by Parsons himself. In the case of big aggregates the use of a wheel of the impulse type is done away with, under certain circumstances, and the whole drop of heat is distributed in two turbine casings. The axial thrust is balanced by the balance-pistons in correspondence with the various stages of the drum, as shown by K1, K2, K3, in Fig. 5. The balance-pistons take part in the rotary movement, and they are stopped up by means of a labyrinth-packing. In order to allow the balance-pistons to obtain a complete compensation of the axial pressure under all kinds of loads, it is necessary that the same pressure act on the pistons as on the drums. This is effected by means of compensating-pipings R1, R2, R3.

It will thus be seen that the re-action-turbine is eminently adapted for the low-pressure field of the steam, and that likewise the construction is a very simple one. As a matter of fact, it does not essentially differ—as far as the principle is concerned—from the original model built by Parsons.

The chief advantages of the impulse-turbine are the following:—As the number of rows of blades required is considerably less than in the case of a re-action-turbine, the construction length is shortened considerably; no reduction of the steam takes place from the inlet to the outlet edge of the moving-blades, so that no unused steam is lost in them. The clearances between the guide and the moving parts may be enlarged as a result of which the safety of working is increased. Only steam of a comparatively low pressure and temperature is allowed to enter the casing of the turbine, since a great deal of the drop in heat is already converted into kinetic energy in the admission nozzles. This is particularly the case with respect to these systems of turbines which have a Curtis wheel connected with their high pressure part. The stresses on the material which are apt to arise in the case of high temperatures are thus avoided. Of great importance is the fact that a partial admission in the case of impulse turbines makes it possible to use, in the first stages, wheels of approximately the same diameter as in the low pressure part. In the case of a partial admission, the guide part is lodged at only a section of the total circumference while in the case of a complete admission the guide blades are lodged on the total circumference. A partial admission is only possible in the case of impulse turbines. If, for example, the pressure at both sides of the moving wheel does not happen to be the same, then the compensation of the pressure

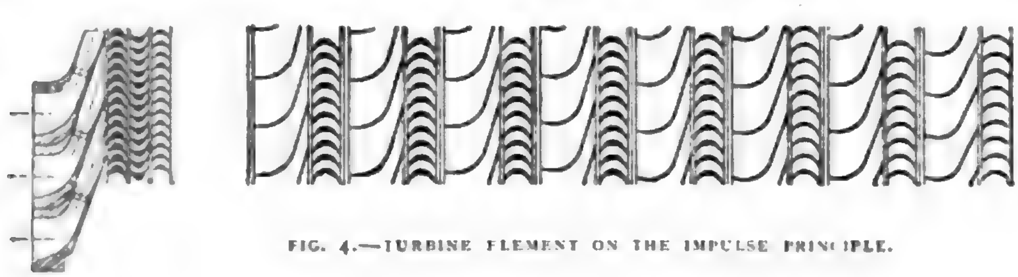


FIG. 4.—TURBINE ELEMENT ON THE IMPULSE PRINCIPLE.

might be easily effected as soon as the moving blades approach those parts of the diaphragm which are not supplied with guide-blades. It thus follows that at the inlet-side of the moving blades alternating pressures would be apt to arise which would have a pulsating injurious effect on the moving wheel and would give rise to eddies that would consume a part of the energy. While it is absolutely necessary, in the case of complete admission, to employ short moving-blades in the high-pressure part which, from a constructive point of view is a great disadvantage, a partial admission permits of an increase in the length of the blades and a reduction in the number of wheels in proportion

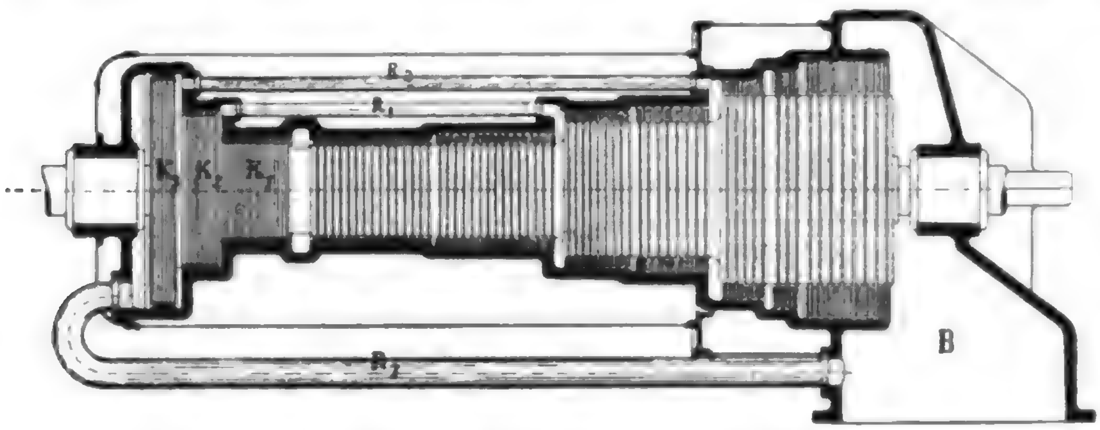



FIG. 5.—BALANCING DEVICE OF A RE-ACTION TURBINE.

as the output of the turbine increases. As furthermore the same pressure exists both in front of, as also at the back of, the moving blades in the case of impulse turbines, the axial thrust is done away with, so that no balancing devices or collar-bearings are required. Only in the case of overload the impulse turbines will work with a slight axial thrust, but this merely requires a small collar bearing to balance it, which serves also to adjust the rotor.

The turbine-casing is as a rule generally made of cast-iron and divided horizontally so that the rotor may easily be examined. Some turbine-builders make use of an undivided cover of cast steel, which they fit on to the governing side. For small turbines, a vertical division of the casing is as a rule selected.

The bed plate is generally made of one solid piece, and only in the case of very big aggregates is the bed-plate divided, and this merely to facilitate either the casting process or the transport. German turbine-makers fill the U-shaped part of the bed-plate with cement in order to improve its rigidity. The bed-plate is only made of cast-iron. The exhaust branch of the turbine is firmly screwed together with the bed-plate, while the governing side of the casing is left movable in guides. The Ljungström-turbine forms an exception, which in consequence of its extraordinarily light weight, may be lodged directly on the condenser.

Turbine and generator together are provided with from three to four bearings. As a rule, it may be assumed that those firms which construct their own generators and which, consequently, combine the generators with the turbine in their own works, prefer three bearings, while the others employ four. The bearings employed are either spherical bush bearings which permit of a slight adjustment of the rotor, sleeve bearings of the Parsons type, which likewise are automatically adjustable, or simple journal bearings. The bearings of the reaction-turbines are screwed together with the bed-plate in order to prevent the heating of the turbine-casing being transmitted to them. In the case of impulse-turbines an extreme heating of the turbine-casing need as a rule not be feared, for which reason the bearings may be fitted directly to the shoulders of the turbine-covers. The sleeve bearings of the Parsons type are employed in the U.S.A. by firms

erecting reaction-turbines, while they are gradually going out of use in Europe since they have been proved to possess various disadvantages. In particular in the event of an insufficient supply of oil a dangerous heating of the single sleeves may arise.

The stuffing-boxes are provided with labyrinth-packing, graphite-carbon-packing, or even water-packing. In Europe, it appears, the water-packing is only made use of by the British Westinghouse Electric and Manufacturing Co., Ltd., by Peter Brotherhood, Ltd., and by Dujardin and Cie. ; the British Westinghouse Co. has adopted this manner of construction from the American Westinghouse concern with which it is affiliated. In the U.S.A. all the concerns which construct turbines of the Parsons type, make use of water-packing. The drawback connected with this last is that it cools the adjoining walls of the turbine casing and thus gives rise to condensation. In most of the reaction-turbines labyrinth packing is used, while the impulse turbines and the combined turbines are generally provided with a graphite-carbon packing.

As a suitable material for the blades of the reaction type, brass or copper is employed. The Westinghouse Machine Company, Messrs. Melms and Pfenninger, as also the Erste Brünner Maschinenfabrik make use of blades which are made of a special grade of bronze. The blades of the impulse type are manufactured of nickel-steel, or, if this be required, of brass. A noteworthy fact is that the nickel-steel must contain a low percentage of nickel, as it would otherwise become brittle after some use and give rise to damaging of the blades. For the Curtis-wheels, blades consisting of an alloy of bronze and nickel or an alloy of copper and nickel are made use of. The blades of the reaction types are always united in segments, and thus fitted into the turbine. Sometimes even the guide-blades of the velocity-stages, in the case of the impulse-turbines, are manufactured in segments. The manufacture of segments can take place in various ways. According to the method introduced by C. A. Parsons in 1907-1908 the root of the blade and the distance piece are provided with a bore through which a brass wire is drawn. This brass-wire may be substituted likewise by a U-shaped pipe or strip of metal. Willans and Robinson put the stamped blades in corresponding slots of the foundation-ring, which consists of drawn brass. The blade-ends are riveted together with a shroud-ring, having a ⊔-shaped cross section. The segments are caulked together with a key-piece into dovetailed slots. The Brush Electrical Engineering Co. places the segments into grooved slots, after which the soft metal distance pieces are caulked into the slots.

The impulse-blades are always lodged in dovetailed-slots. In order to enable them to resist to an improved degree the centrifugal forces which are apt to arise, the lateral faces of the slots are grooved, as in the case of the Tosi-turbine. The Rateau turbines have a type of blades according to which the blade and the distance piece consist of one part, and are fixed on to the outer circumference of the wheel, with which they are riveted.

The admission nozzles are always united in segments of bronze or cast-iron, and are either screwed directly to the turbine-casing or are lodged in a special nozzle chamber, in order to protect the turbine-casing against the temperature arising from the live steam. The nozzles lodged in the diaphragms (in the case of the impulse turbines) are either made of nickel steel and are cast straightway in a cast iron rim, or they are united into segments and are screwed on to the diaphragms. In the latter case they are mostly manufactured of bronze. It is after the first-named method that the Zoelly-turbines are built, while the Rateau turbines are constructed after the second.

The diaphragms are generally divided, and are manufactured of cast-iron. Only in the case of marine turbines they are sometimes made in one solid piece in order to give them more strength, in which case they are furthermore made of cast steel. The

diaphragms are divided for the purpose of preventing the whole turbine being dismantled in the case of nozzle damage.

The drums of the reaction turbines are generally hammered out of Siemens Martin steel, and only in very rare cases are they cast. The shaft journal on the high pressure side is made of one piece with the drum, while it is flanged on the low pressure side, and both shaft-journals are solid. Sometimes both journals are likewise pressed into the drum. In order to prevent a loosening in consequence of a varied heating, Brown-Boveri make use of a bayonet-joint. For the very same reason the drum is also heated by a small quantity of steam within. The Allis-Chalmers Co., and the Westinghouse Machine Co. makes use of a smooth drum, on to which the cast-steel blade rings are shrunk, these being renewable. The Melms-Pfenninger turbines are generally provided with forged-iron drums, which are either rivetted together cold with the moving wheel and the labyrinth, or screwed together.

The balance-pistons of the reaction-turbines are fitted with a labyrinth-packing, and, according to the arrangement introduced by Parsons, are lodged at the governing side. The thrust collars are turned on to the piston, while the labyrinth rings in the casing, which are manufactured either out of brass or nickel steel according to the steam conditions, are caulked into rectangular slots. In the case of the Allis-Chalmers turbine, two balance pistons are lodged at the high-pressure side, while the third is fitted into the low-pressure side. The latter is much narrower than the corresponding piston of the Parsons' turbine, but nevertheless, offers the same efficient surface as the other. The space at the back of this piston is connected for the purpose of balancing with the steam space of the third stage. The balance piping between the high-pressure end and the low-pressure end is not required at all in this case. In the case of the Melms-Pfenninger turbine the balancing of the axial pressure is effected in a most original manner. The annular chamber between the high-pressure part and the low-pressure part in the case of this turbine is constructed in such a manner that the steam pressure charging upon it compensates for the axial thrust of the reaction blades. In the case of the Brown-Boveri-Parsons turbine the balance-piston of the low pressure part is lodged at the low pressure side for the sake of symmetrical construction of the turbine-casing. For the purpose of balancing the axial pressure, the Tosi-turbine is provided with a forced oil piston, which adjusts itself automatically, according to the thrust which happens to exist at the time.

The governing of the Parsons' turbine is generally effected by means of a steam relay, which is under the control of the centrifugal regulator and which actuates the balanced double beat throttling valve. Of late, many concerns building reaction turbines are beginning to introduce oil relay governing in view of the fact that in steam relay governing, the same is dependent on the existing steam pressure. The actuating of the governing valve directly by means of the centrifugal governor without employing a relay has been gradually given up by U.S.A. manufacturers, while Messrs. Willans and Robinson are probably the only ones in Europe still making use of this method. Its great advantage is its simplicity, although the centrifugal governor has to overcome the resistance created by the connecting rods and the governing valve, which may act adversely on its sensitiveness. The advantage of employing forced oil for the purpose of governing is that the supply of live steam to the turbine is automatically shut off as soon as the oil-pump, for some reason or other, ceases to work ; so that it appears impossible for the bearings to run hot. In the case of the steam-relay governing, according to the Parsons' system, and even in the case of some oil relay governing systems, the supply of steam to the turbines is caused to take place in a pulsating manner, in consequence of which the sensitiveness of the governing is considerably increased. In Europe the governing is generally

effected by throttling the steam. The British Thomson-Houston Company, and the French Company affiliated with it, the Compagnie Française Thomson-Houston, both of which construct Curtis turbines, have adopted the automatic nozzle-governing, originated by the General Electric Company. Combined throttling and nozzle governing is further used by the Bergmann Electricity Works, Ltd., and the Machine Works Augsburg-Nuremberg, Ltd. (Man.). In the U.S.A. it is the General Electric Company which exclusively constructs turbines having automatic nozzle governing, while the Allis Chalmers Company and the Westinghouse Machine Company have retained throttling governing.

In the construction of small turbines cheap costs of construction are primarily considered, and the question of economical working plays but a secondary role. It naturally follows that the steam consumption in the case of small turbines is fairly large. It is also for this reason that the small turbine has been developed to a far higher degree in the U.S.A. than in Europe, where, owing to the keen competition, the question of economy plays an important part. For the main part two types of small turbines may be distinguished from each other. The non-condensing turbine, having an axial admission, and consisting of a Curtis wheel, with several rows of buckets, the steam in the admission nozzles being reduced almost down to the exhaust pressure, and the type having radial admission, where the same moving wheel is subjected to a repeated admission by the flow of steam and which likewise works as a non-condensing turbine.

The construction of these turbines is extremely simple, the centrifugal governor directly controlling the throttling valve, in the case of some turbines the emergency governor is done away with. Bronze, brass and steel are used as material for the blades. The stuffing-boxes are provided either with a ring lubrication or metal packing, rarely graphite-carbon rings. All the small turbines work on the impulse principle.

Part II. of this article will deal with the turbines of the principal British makers, while future issues will contain descriptions of turbine practice in other countries of Europe, and in the United States.

# THE NEW LONG RANGE TORPEDOES

THEIR INFLUENCE ON NAVAL TACTICS

**By a Naval Captain**

THE automatic torpedo in outward appearance resembles a cigar, measuring about 6 yards in length and 18 in. in diameter. Its body, made entirely of steel, is composed of four parts inter-connected by means of screws :—

1. The front part (constituting about $\frac{1}{8}$th of the total length) is of conical shape. It is here that the explosive charge is situated, as well as the percussion mechanism for causing the explosion at the moment of impact.

2. The air chamber composed of a cylinder, in which is stored compressed air to work the propelling engine, as well as various mechanical parts

3. The compartment containing the engine and the regulators. The engine consists of a motor of the 4-cylinder Brotherhood type, worked by compressed air. The function of the regulating apparatus, is to ensure the starting of the torpedo at the moment of firing, the regularity of the speed and the depth of immersion during the journey and finally an absolutely rectilinear trajectory.

4. The hind part, shaped like an obtuse cone, is traversed longitudinally by two driving shafts, one of which is placed inside the other. They are connected at the front end to the cranks of the engine, which communicates to them, by means of gearing, rotary movement in opposite directions. At the rear end they each carry a screw with inverse pitch for propelling the torpedo.

The screws are surrounded by a kind of cage (formed of two frames, one vertical and the other horizontal) called the "tail," which supports the rudders, the functions of which are to regulate the direction of run horizontally and vertically. The rudders receive, by means of steel transmission rods, the requisite movements communicated to them by the controlling regulators.

### Historical Survey of the Development of the Torpedo.

The torpedo, invented by the celebrated engineer, Whitehead, in the year 1868, was used for the first time on active service during the war of 1877 between Chili and Peru. Its speed at that time was not more than from 6 to 10 knots. Its maximum range was only about 200 yards. Its diameter was 13 inches, and it carried an explosive charge of $29\frac{1}{2}$ lb. In succeeding types it was the speed that was at first developed, this being the most important factor from the point of view of the chances of hitting a moving target. Then, in view of the increasing strength of the hulls of large warships and of their equipment with water-tight compartments, it was necessary to increase the explosive charge in order to augment the intensity of its destructive effects. Finally, the progress of quick-firing artillery rendering it more difficult for torpedo boats to approach their adversary, the next step was to increase the range.

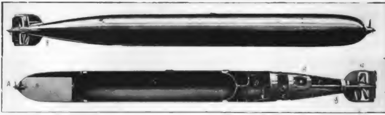
These various conditions led, first of all, to the adoption of larger and larger calibres, but, in this connection, the question of weight intervened, as it was necessary that the torpedo should be capable of easy handling on board ship. It was next towards a more efficient use of compressed air that inventors directed their efforts. It is to the collective results of all these developments that we owe the progress made in torpedo manufacture.

In 1889 the results so far obtained were as follows: Speed 22 knots, charge 165 lb., range 1,650 yards, calibre 15 inches, and weight 930 lb. This was an appreciable advance on preceding types. The 1892 type showed an advance in speed of only 2 or 3 knots, but the charge had risen to 206 lb., and the range to 2,200 yards. These results were obtained by a notable increase in calibre, which rose to 17¾ inches, a figure which was not exceeded for a considerable time. The 1906 type inaugurates a new era, which confers on the torpedo a rôle which will rival that of the gun; its speed is 40 knots, its charge 220 lb., and its range 3,380 yards. The calibre has not changed, but the increase in the length of the air chamber and the introduction of new internal mechanisms have increased its weight to 1,430 lb. At the present moment the 1912 type is being tested in different countries with a calibre of either 18 or 21 inches. The trials carried out lead us to suppose that the maximum speed will be from 45 to 48 knots, and that the range will be at least 6,600 yards. The weight, however, will be 1,980 lb., which will limit the carriage of this weapon to vessels of considerable tonnage.

LAUNCHING APPARATUS.

The torpedo was, at the very beginning, exclusively the weapon of the torpedo boat. Then it was provided on board large vessels, as it was considered that, in the course of a general action, the opposing ships might close in to such a distance as to allow of a torpedo being fired with a chance of hitting its target. After this came the submarine, of which the torpedo was the only weapon and the only *raison d'etre*, though the latest types are being fitted with small quick-firing guns. Each of these different types of vessels had to be fitted with launching apparatus of a different type.

On board the torpedo boat the torpedo can be launched in two ways, either by means of a tube placed forward, in the interior of the hull, and




ABOVE:—EXTERNAL VIEW OF AN 18 IN. "SCHNEIDER" TORPEDO WITH HEATING MECHANISM.
BELOW:—LONGITUDINAL SECTION OF AN 18 IN. WHITEHEAD TORPEDO.

A. Percussion Head. B. Explosive Charge. C. Compressed Air Reservoir. D. Compartment containing Speed and Depth Regulating Mechanism. E. Propelling Motor. F. Shaft. G. Tail with Propellers, and Guiding and Depth Controlling Rudders. H. Position of Gyroscope.

allowing the torpedo to escape through a door opening in the stem (whence its name of "stem" tube or "fixed tube," its position remaining unvaried in the direction of the longitudinal axis of the vessel), or by means of movable tubes placed on deck and capable of being trained to port or starboard at the requisite angles. These tubes are composed of a steel body practically constituting a gun barrel. The torpedo is introduced into this barrel and held in position by means of bolts and brakes. A T-shaped stud on the top of the torpedo slides in a groove provided in the upper part of the tube and serves to guide it. A screwed breech-door closes the tube. Against the inside of the door there is a cartridge containing powder, which, when fired by a firing pin impinging on a detonating tube, propels the torpedo from the tube. The tube is

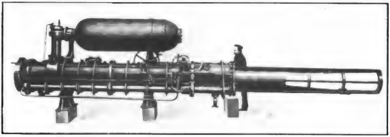
WHITEHEAD TYPE OF ABOVE-WATER TORPEDO TUBE WORKING BY COMPRESSED AIR, FOR SMALL VESSEL.

A. Breech Door. B. Barrel. C. Spoon. D. Firing Lever. E. Firing Lanyard. F. Sight. G. Box in which are kept the Batteries for the Small Electric Lamps, a and b used to Illuminate Sight for Night Firing. H. Aiming Wheel. I. Circular Track for Revolving Tube. M. Gauge Showing Air Pressure. P. Pivot.

prolonged towards the front by a kind of inverted gutter known as the "spoon" which holds the torpedo by its T-stud until the moment at which the screws are clear of the outer opening of the tube.

On board battleships, the arrangement is quite different. In a large compartment situated beneath the main armoured deck there are grouped on each side of the vessel two or four tubes which terminate on the outside of the hull at a certain distance below the armoured belt. These tubes, known as "submerged tubes," are closed at the outer end by a powerful sluice valve which prevents the water from entering. At the other end there is a breech-door which is likewise watertight. A spacious compressed air-chamber is built on to each tube. The torpedoes are introduced into the tubes and the breech-doors are screwed fast. The compressed air of the chamber is then made to work a piston which pushes to the outside of the vessel a "spoon" of a special shape. Prolonging the tube, not *on the top*, as in the case of the torpedo-boat, but *at the side turned towards the vessel's head*, this "spoon" forms a screen to protect the torpedo, while it is issuing from the tube, from the action of the swirl of water which is produced by the speed of the vessel, and which would drive the torpedo towards the stern.

As soon as the spoon is in position, the sluice is opened and communication established between the tube and the water. To effect the launching opera-



SUBMERGED TYPE OF TUBE AS USED IN THE FRENCH NAVY SHOWING THE PROTECTIVE "SPOON" IN POSITION FOR FIRING.

tion, a jet of compressed air is introduced into the tube behind the torpedo, which is thus driven outwards. As soon as it is clear of the tube the water flows in and fills it. The water sluice is then closed and a valve opened, which allows the tube to be immediately emptied and prepared again ready for a fresh charge. The spoon is withdrawn, as soon as the torpedo has been fired. Efforts are at present being made, particularly in Germany, to shorten as far as possible the time required for loading the tube to allow of torpedoes being fired at extremely close intervals.

Submarines employ either a stem tube, fixed in the same way as that on board torpedo boats (but arranged with a view to under-water firing, on the same principle as the submerged tubes of large vessels) or apparatus installed on deck and consisting of a simple framework arranged for certain training movements, which can be effected from the inside of the vessel. The firing operation is effected by releasing a mechanism that opens direct the valve for starting the torpedo, which shoots from its framework-tube of its own impulse.

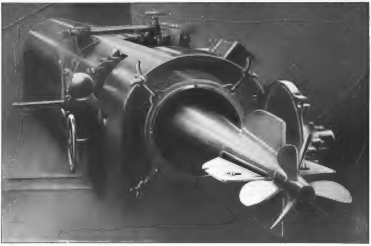
WORKING OF THE TORPEDO.

On issuing from the tube, the torpedo throws over a lever projecting above it, and this lever opens a valve which establishes communication between the compressed air chamber and the propelling apparatus. The engine starts working, the screws forthwith begin to revolve and the torpedo gets up its speed.

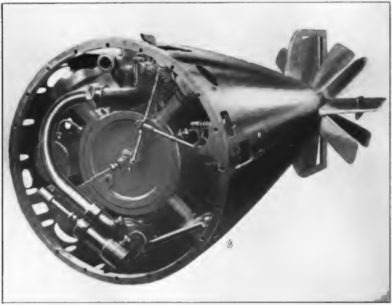
It has now to travel under water at a determinate depth, in order to strike the hull of the hostile vessel sufficiently low down to ensure the explosion producing its maximum effect and yet not so far below the water line as to glance on the tapering part of the vessel's bottom.

The depth of immersion is generally about 3½ yards. It is on an ingenious apparatus known as the "immersion regulator" that devolves the function of keeping the torpedo at this depth. This apparatus consists of a piston, one of whose faces is in contact with the sea through the intermediary of an elastic membrane, while the other face rests on a spring, the tension of which has been previously regulated to correspond to the pressure of the water at the required depth

If the torpedo sinks too far, the water pressure increases and tends to drive the piston back again into the



TORPEDO BEING INSERTED IN TUBE.



ENGINE COMPARTMENT OF A TORPEDO NOT EQUIPPED WITH HEATER, BROTHERHOOD MOTOR.

interior of the torpedo. This piston, in its rearward movement, works a rod which transmits, by means of various multiplying devices, a lifting movement to the horizontal rudders fixed at the rear end of the torpedo. Under the influence of these rudders the torpedo rises. Should it rise too far, the inside spring pushes the piston outwards (the pressure of the water being less than that for which it has been set) and the rudders are made to work in the contrary direction. The torpedo plunges again and after a few oscillations in the vertical plane, it assumes its definite depth of immersion, which it thenceforth maintains.

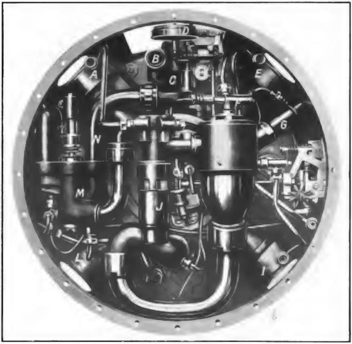
To diminish the range of these oscillations, a heavy pendulum is provided to complete the mechanism. When the head of the torpedo commences to rise or tends to plunge, the pendulum likewise acts, by its inertia, in the requisite direction on the rod which serves to operate the depth-regulating rudders. The undulatory movement of the torpedo in the vertical direction is thereby rapidly neutralised.

It is also essential that it should maintain an absolutely rectilinear trajectory in the horizontal plane, in order to strike the point aimed at. This *rôle* devolves on its self-directing gyroscopic mechanism, the principle of which is analogous to that of the well-known toy, the gyroscopic top.

The torpedo must maintain a uniform speed throughout the whole of its run. To attain this end, the air passes, on issuing from the chamber and prior to being led to the engine, through a "pressure regulator" which automatically regulates it to a uniform pressure.

Modern torpedoes are equipped with an air heater, a device which constitutes the main cause of all the progress recently made. Its method of working is as follows:—At the moment of starting and after the screws have made a certain number of revolutions, a special mechanism is automatically

released under the influence of the torpedo's forward movement. This mechanism works a firing pin which strikes a cartridge. This cartridge is ignited and deflagrates. The flame produced burns in a special apparatus into which, on the one hand, an air pipe injects some kind of fuel (ethyl alcohol, benzine, petrol, or attendant on the injection of fresh water is that it lowers the temperature in the engine cylinders to 200°; the energy of expansion is more than doubled, a fact which results in a notable increase in speed. This saving in the consumption of compressed air enables the torpedo to cover twice as long a distance with the same air supply.



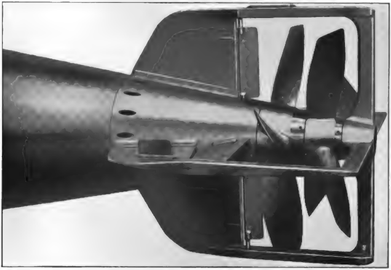

ENGINE COMPARTMENT OF A TORPEDO EQUIPPED WITH HEATER.

A. Distributor to No. 4 Cylinder. B. Tube Conveying Compressed Air from Reservoir. C. Valve. D. Distance Regulator. E. Distributor to No. 1 Cylinder. F. Petrol Injector for Superheater. G. Mechanism for Lighting the Petrol. H. Superheater. I. Distributor to No. 2 Cylinder. J. Governor for Preventing too Rapid Revolution of the Screws while Torpedo is not Sufficiently Deep. L. Distributor to No. 3 Cylinder. M. Pressure Regulator. N. Air Supply to Pressure Regulator.

"thermite") while, on the other hand, an injector feeds into it fresh water contained in a tank placed on the inside of the rear cone of the torpedo.

The compressed air on its way from the air chamber to the engine traverses this apparatus, becomes heated to 300° and expands. The advantage

At the nose of the torpedo is a small screw, which set in motion by its speed, releases a firing pin, this pin is previously locked, in order to prevent any premature explosion in the event of the torpedo receiving an accidental shock prior to its being fired. Henceforth the firing pin is cocked and the



TAIL OF "WOOLWICH" TYPE TORPEDO, SHOWING PROPELLERS AND RUDDERS.

slightest shock of the point against the hull of the hostile ship will throw it backwards; it then strikes a primer which brings about the explosion of the whole charge, composed of gun cotton or any other powerful explosive.

This explosion causes an outward surging of the water all round the point of impact, under the enormous pressure due to the expansion of the gases, this causing the physical phenomenon known as the hydraulic ram. The water thus displaced returns with equal violence, and, after the manner of a ram, shatters the hull by widening the breech.

Some of the breaches produced by torpedoes on various vessels (war between Chili and Peru and Russo-Japanese war) measured from 17 to 21 square yards.

The problem of the method of defence to be adopted against this action of the torpedo has not yet been solved. Vessels riding at anchor may protect themselves against it by surrounding themselves with Bullivant nets with steel meshes, rigged out at a few yards from the side by means of booms. The idea is to catch the torpedo in the net, but sometimes it cuts through the latter with a special mechanism known as a "net-cutter," which it may be equipped with. When at sea, however, nets hamper the speed of the vessel too much to be adopted. Various systems of bulkheads and division of battleships into compartments have been tried, though so far their efficacy is still very uncertain.

When it is desired to fire a torpedo at a vessel riding at anchor, the operation consists in approaching to a suitable distance, and in manœuvring in such a way as to launch the torpedo as nearly as possible perpendicular to the lie of the hostile ship, while aiming at the centre of its hull.

When the target is a moving one, the problem becomes more delicate, as three factors have to be taken into account, namely the line of route followed by the target, its speed and the distance which the torpedo will have to traverse in order to strike it. On the accuracy of all these calculations success depends.

When a torpedo boat perceives a battleship, it manœuvres to follow a line of route parallel to that of the enemy, and in the contrary direction. It endeavours to pass at a distance from the target appreciably less than that which its torpedo can cover. At the moment of firing its projectile, its position is such that the period during which the battleship will be moving onwards prior to being struck is equal to that required by the torpedo to reach its target. The importance attaching to the speed of the torpedo as a factor in the diminution of the chances of failure is obvious.

At the present time, in consequence of the introduction of the new torpedo with a large radius of action, we are witnessing a complete revolution in its tactical employment. The torpedo boat and the submarine will, of course, always have their place in the attack by surprise or ambush, the one acting at night and the other in the daytime, but besides this we have now quite a new use for them, admitting of the torpedo being utilised in the attack at *ranges varying from* 5,500 *to* 7,000 *yards*.

It is obvious by night a torpedo attack at so great a distance would be impossible. Not only would it be impossible to estimate the factors of firing at this distance, but the target would be invisible. It is thus by day that the long range attack will be carried out. We will proceed to see under what conditions.

### Tactical Employment of the Modern Torpedo.

The chances of hitting the target diminishing with the increase in the range, it is necessary in order to retain sufficient probabilities of success, to increase the zone swept by the torpedoes by firing a large number of them together in the form of a kind of sheaf to be given a suitable direction.

This is the origin of the idea of executing the attack by day with a flotilla of torpedo boats against a group of battleships. The classic formation of battleships in a general action, a formation which has been imposed by the requirements of artillery fire and the ease of manœuvre, is line ahead. The vessels follow each other at a distance of 350 yards or 450 yards, forming a total length of line of from 3,000 to 4,500 yards. It is this line which will constitute the target.

If we bear in mind that the only vulnerable part of all this length of line is the part represented by the total length of all the hulls in it, we realise that the probabilities of hitting with a sheaf of torpedoes fired at the formation will be about 40 per cent. if the distance between the battleships is 350 yards, and 33 per cent. if it is 450 yards.

Let us suppose a flotilla composed of four large torpedo boats of 800 tons, each equipped with four torpedo tubes capable of firing all together on the same broadside.

At the moment when the action opens between two squadrons, each battleship is primarily concerned in strictly maintaining its line of route in order not to interfere with the fire control of its heavy guns, as any falling-off in the efficiency of its fire constitutes a superiority conferred on the enemy.

While the action is developing between the two hostile lines steaming on opposite tacks, the torpedo boat flotilla will attempt to attack the enemy on the side opposite to the squadron of its own side. This flo illa will, at the moment of firing its torpedoes, be at a distance of about 7,000 yards from the enemy's battleships. The flotilla steaming at 30 knots and the enemy's ships at 20, the difference in speed is 50 knots. At such a speed, and considering the small surface it presents to the fire of the enemy's guns, it is almost invulnerable. It will thus be able to fire, at one discharge, against the line of route followed by the enemy's ships, 16 torpedoes directed fanwise in such a way, that the two trajectories of the end torpedoes will embrace the line which forms their target. Judging by the probabilities of hitting we have just considered of the 16 torpedoes fired, 6 or perhaps 5, have a chance of striking home.

Then one or two things will happen: either the enemy, seeing the torpedo menace, will manœuvre to avoid them, and be thereby obliged to interfere with his firing service, thus conferring

the artillery advantage to his opponent, or he will continue his way and cross the line of the torpedoes, in doing which several of his units may be either annihilated or at least put *hors de combat*.

Such is one of the possible cases showing the new role which the modern torpedo will be called upon to play in the course of an action.

The cost of a torpedo, which did not exceed £200 in 1877, is now as much as from £600 to £800. This suffices to show the importance of this branch of manufacture, dealing with apparatus of considerable weight, the accuracy of which must be equal to that of the most delicate clockwork.—(*La Science et La Vie*).

# BOILER FURNACES

By John Batey

THE furnace of a steam boiler is a laboratory in which some of the most difficult combinations of gases are produced, but under conditions impossible to the chemist; yet the majority of steam boiler users merely look upon it as a place in which fuel is burnt—more or less, for the purpose of making steam. The heat given off by burning is of two characters of varying amount—due to a variety of temperatures resulting from the use of quantity, or difference, in fuel value, and the amount of air admitted to the furnace.

Amongst the many delicate operations conducted within the boiler furnace laboratory, temperature and radiant heat value are two determinations difficult to regulate, even to making it a well-nigh hopeless task to ensure a regular sequence. Temperature is largely determined by sight, though, sometimes, it is roughly gauged by the fusion of metals of known melting points; but such gauging is merely approximate. The pyrometer is the best method, but even that is not to be relied on, and all methods are largely experimental. One rule for finding temperature and radiant heat value is "Peclet's." The method is intricate and laborious, and the result is only reached by a system of trial and error, but it is a practical rule, given in full, as follows:—

$R = 144a\ \phi\ (a'—1.)$ where $R$ = the heat radiated, per square foot of grate surface, per hour in B.Th.U. terms.

$\phi$ = the temperature of the receiving medium, steam or water inside of the boiler in Fahrenheit degrees.

$a$ = a constant, 1,00425.

$t$ = the excess temperature of the assumed fire surface above that of $\phi$, also in Fah. degrees.

By this rule, Mr. D. K. Clark furnished a table of temperatures and heat values, for quantities of fuel ranging from 5 to 120 lbs. per square foot of grate. The table is based on the condition of perfect combustion.

As the table is of little use in practice, the author of the article has plotted another table, based upon the use of 50% excess air, but deduced from Peclet's rule, and is useful for practical purposes. A graphic diagram is also given to show the marked difference a few degrees make in quantities of heat. (page 306).

The tables follow in sequence:—

D. K. CLARK'S TABLE.

TEMPERATURE AND HEAT OF A COAL FIRE IN A STATE OF INCANDESCENCE.

*Conditions.* Complete combustion. No excess air. Estimated B.Th.U value of fuel 14,700.

| Coal per sq. ft. of grate per hour. | $\theta$ Tem. inside boiler. | $t + \theta$ Tem. surface of fire per sq. ft. | Radiant Heat. | Convected heat. | Sum of R + C. | Total heat estimated. |
|---|---|---|---|---|---|---|
| lbs. | Fah. | Fah. | Units. | Units. | Units. | Units. |
| 5 | 350 | 1,400 | 53,960 | 19,160 | 73,120 | 73,500 |
| 10 | ,, | 1,550 | 102,500 | 43,510 | 146,010 | 147,000 |
| 20 | ,, | 1,705 | 198,400 | 94,080 | 294,480 | 294,000 |
| 40 | ,, | 1,857 | 378,650 | 209,850 | 588,500 | 588,000 |
| 80 | ,, | 2,009 | 721,800 | 455,400 | 1,177,200 | 1,170,000 |
| 120 | ,, | 2,097 | 1,049,000 | 714,050 | 1,763,050 | 1,764,000 |

Approximately the temperature of combustion is 5,158°F.

Approximately the temperature of combustion is 5158° F.

In practice perfect combustion is not expected, therefore the author's table for 50% excess air is given for slightly different quantities of coal.

The temperature of combustion is the total of all the heat indications of the separate elements, which do not remain separate on combustion, but become combinations of elements, and such combinations necessarily involve a reduction of elemental or separate temperatures whereby the heat is suppressed as in the case of $H_2O$., where two volumes of H combine with O and become equivalent to a two volume capacity, because the volume is absorbed out of 3. The heat value of the combination is that of the three volumes, but the temperature is the equivalent of two separate temperatures, and the same occurs in regard to $CO_2$, though O is not a combustible. Its separate volume takes in heat as a separate element: but in combination with C half the heat of $O_2$ is suppressed, and is not indicated as temperature, therefore as separate elements three volumes of heat are present, and of course three

AUTHOR'S TABLE.

| Coal per sq. ft. of grate per hour. | $\theta$ | $t + \theta$ | Radiant. | Convected. | R + C | Total estimated. |
|---|---|---|---|---|---|---|
| lbs. | Fah. | Fah. | Units. | Units. | Units. | Units. |
| 5 | 328 | 1,366 | 46,669 | 26,930 | 73,599 | 73,500 |
| 10 | ,, | 1,512 | 87,215 | 59,899 | 147,114 | 147,000 |
| 12 | ,, | 1,550 | 102,552 | 73,763 | 176,315 | 176,400 |
| 15 | ,, | 1,559 | 124,254 | 94,992 | 219,311 | 220,500 |
| 20 | ,, | 1,658 | 162,451 | 131,860 | 294,311 | 294,000 |
| 40 | ,, | 1,803 | 301,000 | 287,680 | 588,680 | 588,000 |
| 80 | ,, | 1,946 | 552,519 | 622,079 | 1,175,079 | 1,176,000 |
| 120 | ,, | 2,030 | 788,817 | 975,488 | 1,764,305 | 1,764,000 |

The temperature of combustion is, approximately, 3,558°F.

The temperature of combustion is, approximately, 3558° F.

By comparing the two tables for equal weight of fuel burnt it is seen that the introduction of 50% excess air reduces the temperature of combustion 1,600° F. (about), or for 5.3 lbs. of excess air, each lb. absorbs nearly 302° F., equivalent to 380 B.Th.U. Temperature measures intensity of heat, but not quantity, because the temperature of a unit volume of gas has the same temperature as the total volume from which it is taken and though this is true, yet the unit volume of a 10,000 unit volume only refers to quantity of heat as a proportion, or 1–10,000, yet the temperature for both volumes may be the same.

separate temperatures: but as $CO_2$ half of the O is suppressed. The temperature is for one volume of O and one of C. Thus, the theoretical temperature of combustion may be accounted for in boiler furnace practice.

By reference to a comparison of the two tables, where 1 lb. of coal is completely burnt in conjunction with 10.7 lb. of dry atmospheric air, the reduction of the temperature of combustion by the admission of 50% excess air shows that each lb. of excess air accounts for 302° F., therefore 5.3 lbs. of excess air accounts for a reduction of 1,600° F. With such deductions it is interesting and important to portion out the temperature of combustion by various allocations.

For the ideal condition the approximate value of the temperature of combustion is 5,158° F., but 10.7 lb. of air accounts for 3,200° F., leaving 1,958° F. to be otherwise accounted for. The products, for perfect combustion weigh 11.7 lb., of which 10.7 are accounted for, leaving 1 lb. to be examined in regard to its influence on the temperature value. In this lb., which is fuel, is included 80% of carbon, 5% of hydrogen, 8% of oxygen, and 7% of other gases, all of which have actual or putative, separate volumes, of varying specific heat, and these several elements in some way account for the temperature of 1,958° F., being the surplus value of the temperature of combustion, after 10.7 lb. of air influence has been deducted. The total weight of the products are invariable for given conditions, but the final volume is contingent on their combination volumes. For instance, two volumes of hydrogen combine with 1 of oxygen, but the combined volume is only two-thirds of the total elemental volumes. A similar effect is produced by the combination of $CO_2$, &c., but it is not so for CO.

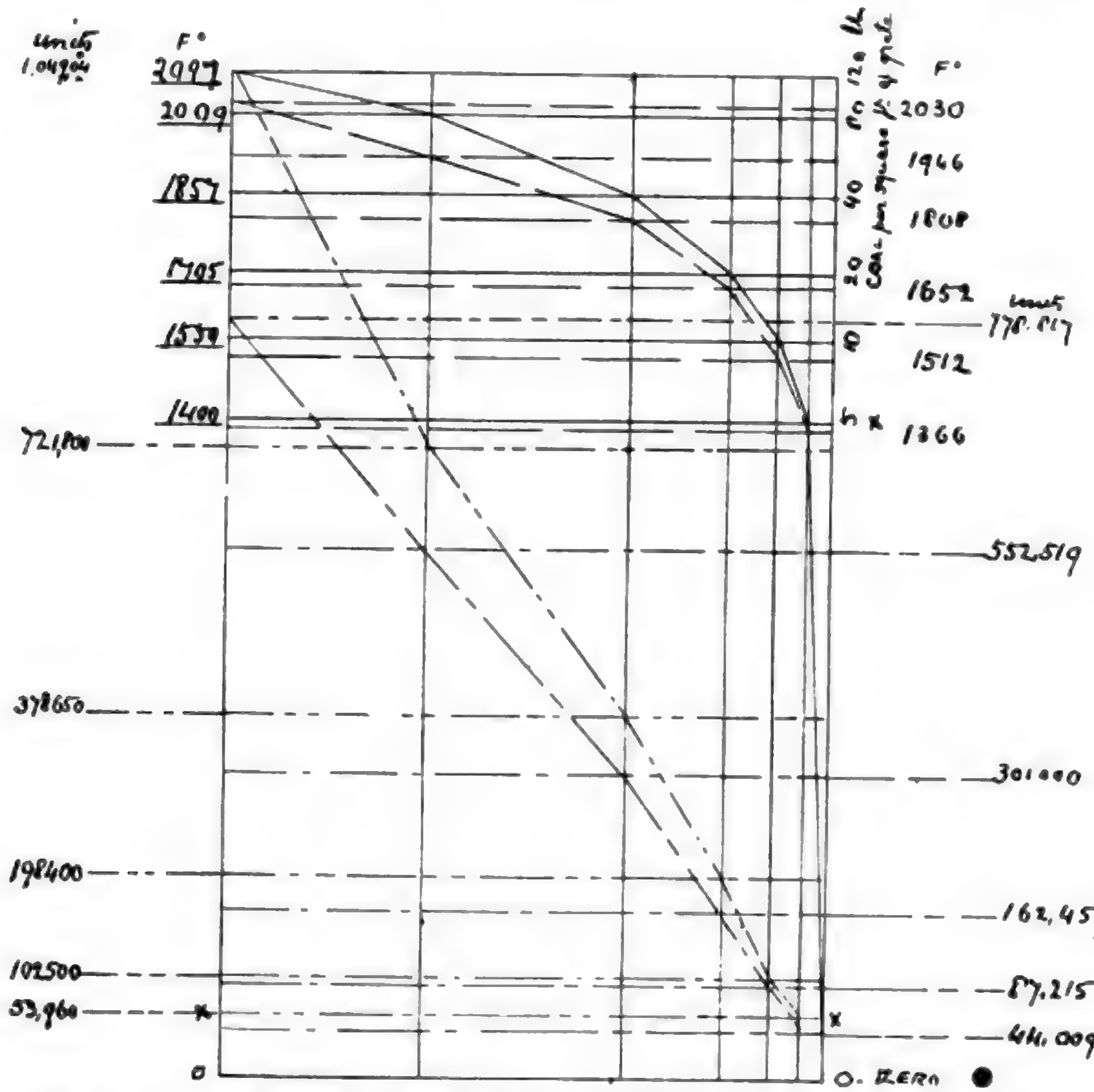
Though $CO_2$ and $H_2O$ are the principal combinations others occur, and must be considered: including the oxygen and other gases, which are referred to 95% of the carbon section: thus 5% remains for the hydrogen. Various other possible combinations of these two will give a faint idea of the difficulty attending accounting for the remaining 1,958° F. As the temperature of combustion is ascertained by dividing the estimated heat value of the fuel by the units required to raise the temperature of the products 1° F., so, in a similar way the average temperature value of the elements in the lb. of fuel, under consideration, may be defined. Worked out these will only account for 457° F., leaving 1,500° F. unaccounted for, except by the temperature of the fire.

There is reason for calling attention to the great loss of temperature owing to the introduction of excess air, which is probably the cause of low efficiency, so often found with the average steam plants. Thus, a great advantage is gained by knowing the real value of the products outside of the air element. It is sufficient to point out that the admission of excess air if 50% excess air reduces the temperature of combustion 1,600° F., and the temperature of the fire surface 34° F. It is quite obvious that 34° F. reduction of fire surface in some way causes the loss of 2,000 B.Th.U., and that will be accounted for by the extra nitrogen volume and the excess waste of gaseous product by weight. By such deductions 75% excess air reduces the temperature of combustion 2,392° F., and 100% 3,200° F., and the temperature of the fire surface in proportion to the preceding relative values. Generally, it may be said that when burning 12 lb. of average coal in conjunction with 50% excess air, per hour, the practical limit of natural chimney draught is reached, and that occurs when the fire surface is 1,550° F.

Radiant heat is six times as active as convected—though its effect is confined to furnace heating surface; therefore, allowing excess radiant heat beyond what furnace heating surface can absorb is a mistake; so that to know how much radiant heat results from a given fire temperature is important. Radiant heat roughly follows increased amounts of coal burnt, though not quite; but temperature has a marked effect on quantity. In practice about 25 per cent. of all radiant heat is lost to

evaporation by the fire-bar spaces, and another 3 per cent. by the ends of the fire, due to dissipation by the fire door and bridge to atmosphere from the ordinary cylindrical furnace; besides, about 5 per cent. is transferred to the flue surface beyond the bridge in the Lancashire type; or to the tube ends in the multitubular. Another 5 per cent. evaporation is due to radiant heat; the other 50 per cent. being credited to gaseous effect, but fully 10 per cent. of convected heat is carried away by the waste gases and another 25 per cent. is lost by the brickwork, flues, &c., in Lancashire boilders.

Take the case of 12 lb. of coal per square foot of grate for 50 per cent.




The top curves in both cases are for perfect combustion and the lower for 50% excess air. Figures on extreme left equal radiant heat value for perfect combustion in unit terms. The next row represents the temperatures. On the right the temperatures and unit amounts are for 5% excess air. The radiant heat diagram on XX line if placed on X line of the temperature shows the rise.

is included in the small coal and dust; that reduces the quantity of combustible burnt. Thus, 40 per cent. of the total estimated radiant heat is lost to furnace evaporation. Generally, it is assumed that 50 per cent. of the total excess air; then, as per writer's table 102,552 units of radiant heat minus 40 per cent. = 62,532 units used in evaporation. Convected heat equal 73,763 plus (5 per cent. of 102,552) 10,255 = 84,018 units, minus 35 per

cent. = 65,023 units, or practically equal to the other. Now 130,555 units are usefully employed in evaporation, representing an efficiency of 73 per cent. about. From authorised tests made at the Philadelphia Exhibition many years ago an efficiency of 69 per cent. was obtained from a Galloway type Lancashire two-flued boiler, which has not been met or excelled since; therefore, the deduction is too great an efficiency; but 65 per cent. is common in good practice; therefore, 8 per cent. has to be accounted for. Probably 2½ to 3 per cent. of this is due to radiation from the plant surface; and another 5 per cent. to CO carried off in the waste gases as unconsumed combustibles.

Referring the 25 per cent. loss of convected to the total estimated heat, the loss is 10 per cent.; therefore, in boilers that require no brickwork flues it should be possible to get 75 per cent. of efficiency. This is possible, and many cases are known where it has been reached, and the writer witnessed one set of experiments with marine boilers, where 75 per cent. efficiency was shown, and was actually attained. These efficiencies may be increased whilst gaining a higher quantitative efficiency.

Forty lb. of coal per square foot can be burnt in a marine boiler furnace; in fact it is common practice, and in a few cases with little loss to economical fuel efficiency. Advantage may be taken of the possibility of subjecting the gaseous products to compression by increasing the draught and restricting the outlet to the chimney. The advantage obtained would be due to a hotter fire and a more active radiant heat, and a hotter gaseous product whose increased temperature, under the compressing effect would transmit more heat to the given heating surface, without sensibly increasing the chimney temperature. As a fact chimney temperature need not be added to.

Where a forced draught enables four times the natural draught effect to be produced without lowering efficiency, to get four times the quantity of steam from an element hitherto giving one, means true economy, but under careful handling and constructive ingenuity an economical efficiency of anything from 2½ to 5 per cent. is possible, or more. Generally, an average efficiency of 40 per cent. of all boilers is all that rules; therefore, to increase the efficiency to 60 per cent. average is what all users and makers of such plants should seek.

In connection with what has already been said in regard to boilers of the Lancashire type a balance sheet is given from which much may be learnt. The percentage values will be the same, however much coal is burnt, and whatever the economy may be; therefore, it will serve a useful purpose as a guide to general practice. The values are only approximate; but a closer analysis will fully qualify them. The values in per cent. terms are referred to the estimated fuel value; but to the two heats as separate values in detail.

Radiant heat losses:—

| | | |
|---|---|---|
| To ashpit by fire-bar spaces .. .. | 25% | |
| By bridge and fire-door | 5% | |
| By small coal and dust | 5% | |
| By heat transferred to behind bridge .. | 2.8% | |
| By general radiation .. | 3.2% | =31% |

Convected heat losses:—

| | | |
|---|---|---|
| By waste gases .. | 10% | |
| By brickwork .. .. | 25% | = 35% |

Another loss of 5 per cent. is due to CO being carried off by the waste gases, but the insertion of cone tubes will increase the efficiency by 3 per cent.

Worked out, the efficiency is, roughly 65 per cent., but there seems no reason why it should not be raised to 70 per cent. One thing is important, viz., chimney temperature, which need not exceed 400° F. to suit usual pressures. Efficiently clothing all exposed surfaces with non-conducting material is essential.

It is impossible in an article of this length to do more than merely generalise, but one matter must be touched upon, being the conductivity of metal plates, and an object lesson has been set by one square foot of furnace heating surface in a locomotive which

transmitted 72,000 B.Th.U. per hour, whilst 60,000 is common to good fair practice. In connection with locomotive practice a few notes may be of use.

The fire may be replenished 12 times in the hour with 37 lb. of coal, which may mean 5 shovel loads, or 60 per hour, and allowing three seconds per shovel, 180 seconds, or three minutes of open door occurs per hour. For perfect combustion 672 cubic feet of air is required per minute, admitted by the fire-door spaces; this means ½ lb. of air per square foot per second; or 90 lb. in three minutes, which requires 43,500 units to raise it to furnace temperature; call it 50,000, or .04 per cent. of the whole performance. Another loss is due to excessive blowing off steam at the safety valve, which easily means 4 lb. weight per minute for a slight lift of the valve. Cases are known where steam has been blown off viciously for over 40 minutes, involving probably the waste of over 200 lb. weight of steam, which means, roughly, 25 lb. lost, say, 1 per cent. of the total performance; therefore, it is within the bounds of possibility to waste 2 per cent. of locomotive efficiency by careless handling.

To assert that such happenings are rare is untrue, because they frequently occur, and are of much greater loss than that named.

Many a furnace door is kept open whilst a train is in the station for five minutes, and in stationary plants clearing a fire may be delayed whilst the manipulator is indulging in a five minutes' chat, and all the time the fire is cooling by taking big indraughts of cold air.

In endless ways the poor efficiency of boiler plants in general is still further reduced by improper attention. Some efficiency may be caused by piling on cold fuel to save frequent periods of attention, not that the fireman is lazy, but by reason of having so many duties to attend to besides the boiler, and the result is low efficiency and loss of money. The above are remedial faults, but others mentioned are due to want of real knowledge, or the non-use of it. In any case, it means loss of money, and only when the intricate nature of the boiler laboratory is understood can we expect to get better results at less cost.

If this article serves no better purpose than to call attention to a somewhat neglected subject, its purpose is achieved.

# THE ELECTRIC REFINING OF STEEL IN AN INDUCTION FURNACE OF SPECIAL TYPE.*

**By Otto Frick**

THE development of the electric steel furnace in the past and its progress in the present have so often been described and discussed from a general point of view, that the author proposes to devote the greater part of this paper to the future development of the electric furnace, not so much from a general point of view as from that of the use of the particular type of *induction furnace* with which his name is associated. The conclusions arrived at are mainly based on results obtained in the ele tric furnaces at Krupp's works in Essen, and serve to show that whatever the history and present position of the electric furnace in the steel industry, its future possibilities are such that it may be anticipated that a time will come when half the steel produced will have been passed through the electric furnace.

Two furnaces of the Frick type are at work in Essen. The first furnace came into regular operation in August, 1908. The second furnace, originally of the Kjellin type, was rebuilt on the same principle as the first Frick furnace, after this had been proved superior both in design and with regard to power, consumption and efficiency.

The data relating to these furnaces are :—

| | |
|---|---|
| Raw materials .. .. .. | cold scrap of good analysis |
| Holding capacity .. .. | 10 tons |
| Kilowatts for which furnace was designed .. .. .. | 736 |
| Actual working capacity .. | 8·5 tons |
| Weight of casts .. .. .. | 0·5 „ |
| Average power used .. .. | 650 kilowatts |
| Frequency .. .. .. | 5 cycles per sec. |
| Voltage .. .. .. .. | 5000 |
| Power factor, cosine $\phi$ at 8·5 tons .. .. .. .. | 0·53 |
| Average duration of one heat | 6 hrs. 45 mins. |
| Theoretical energy, consumption, per ton .. .. .. | 432 kilowatt hrs. |
| Average electrical loss.. .. | 4·5 per cent. |
| Average radiation loss.. .. | 160 kilowatts |
| Average total efficiency .. | 70 per cent. |

Figs. 1 and 2 give a clear idea of the design of the furnace. The photographs (Figs. 4 and 5) show views of the furnace and plant.

ROTABLE COVER.—As the furnace was to be used for melting cold scrap only without any refining, the original type with a rotable cover was chosen, specially designed for the treatment of cold scrap and offering the advantage of easy charging and distribution over the whole crucible without any delay or trouble. The rotable cover further facilitates the supervision of the metal and of the furnace walls. Additions of slag or alloys are quickly and evenly distributed over the bath. The design of the cover has proved most satisfactory for its purpose.

LOSSES AND EFFICIENCY.—The most essential points with regard to the design of electric furnaces are the efficiency and power consumption. The efficiency is dependent alone on the care with which the losses, consisting of electric losses and radiation losses, are kept down.

The electric losses, that is, the losses in the primary coils and in the magnetic iron core, are reduced by giving these parts ample dimensions. Notwithstanding the great weight of the core, nearly 45 tons, the total electric loss in the furnace in Essen only amounts to 4·5 per cent. of the total energy supplied to the furnace. Of greater influence on the efficiency are the losses due to radiation. The author has made a careful study of the heat conductivity of refractory materials, and the furnaces in Essen have been provided with insulated walls in accordance with the results.

* Abstract, together with some additional data, of a paper read before the Iron and Steel Institute, specially prepared for "Cassier's Engineering Monthly" by the author.

At the Krupp works also a Girod furnace of 1,200 kilowatts and 12 tons capacity has been installed next to the Frick furnace, thus giving an opportunity to compare the Frick furnace with a furnace of the arc type.

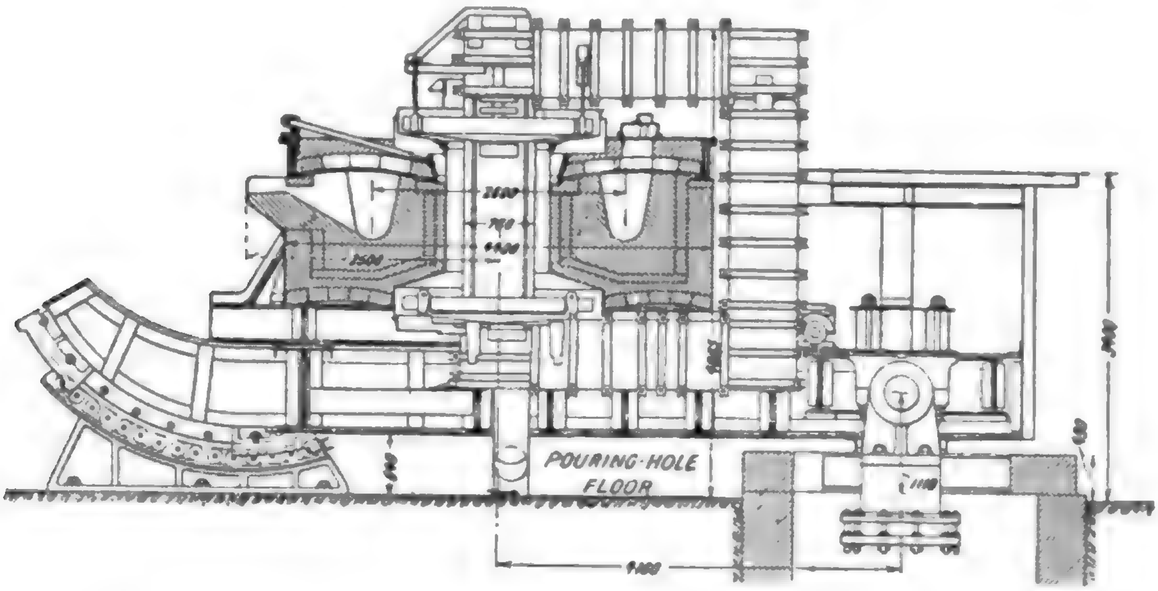



FIG. 1.—LONGITUDINAL SECTION OF 10 TON, 1000 H.P. FRICK ELECTRIC FURNACE.

The superiority of the non-arc furnace does not only depend on the better heat insulation of the former furnace, but is also founded upon the difference between the methods of heating.

In an arc furnace the essential part of the heat is generated in the arc or arcs playing between the ends of the electrodes and the metal, and consequently the heat has to be transferred from these centres to the other parts of the bath by heat transmission, which requires a very high temperature in the arcs and at the lower end of the electrodes, a temperature which certainly exceeds 2,500° C., whereas the highest temperature in a Frick furnace never exceeds 1,680° C. at any part.

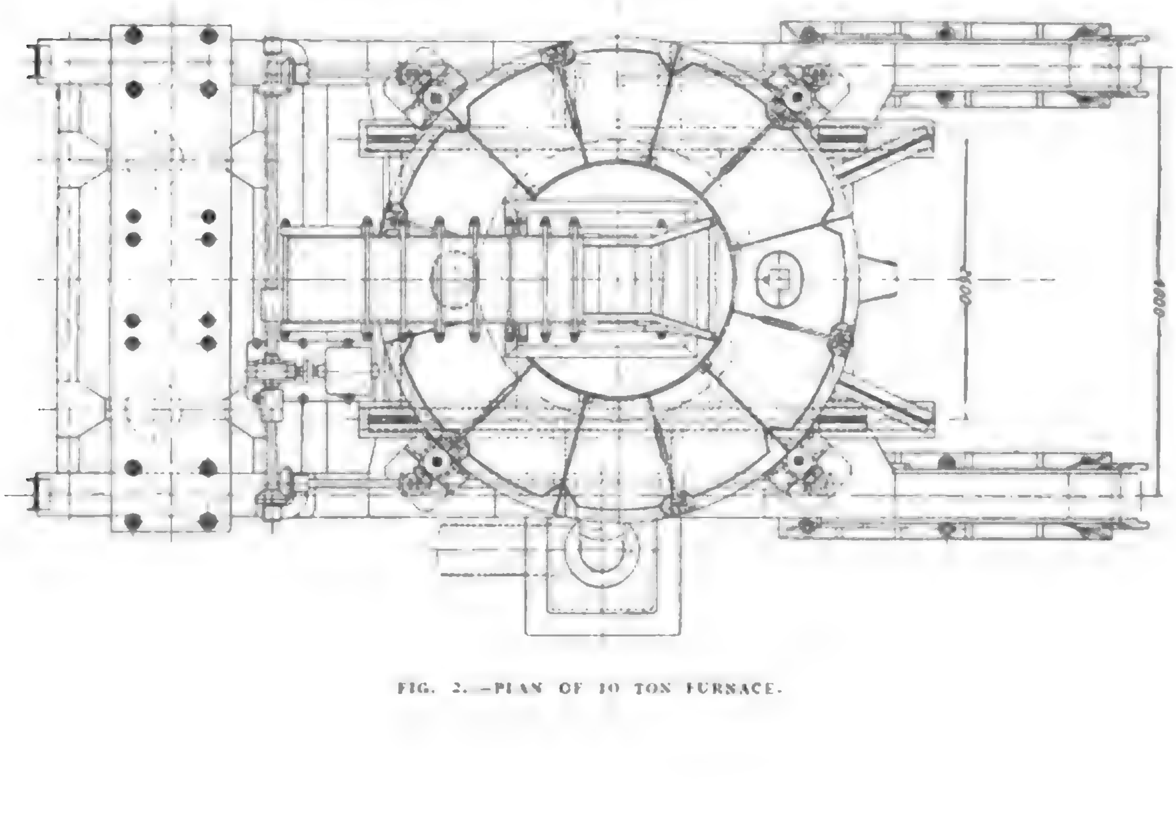


FIG. 2.—PLAN OF 10 TON FURNACE.

The heat generated in the arc is spread in all directions, and according to the existing laws of nature the greater part of the heat will go in the direction of the least resistance.

It may be said with fair accuracy that at least half of the heat will be carried towards the roof and the upper part of the furnace-walls. In treating liquid steel even more than one-half will take this way. This becomes evident by considering, how the heat transmission from the arc to the roof is facilitated by the gases which circulate above the bath, and how much shorter the way to the outside is through the thin roof as compared with the brickwork underneath the bath.

LINING.—With regard to the lining the induction furnace offers certain intrinsic difficulties through the ring-shaped form of the crucible.

The lining in Essen was the outcome of most extensive researches and much experimental work; it is made of magnesite of the highest purity, preferably up to 93 per cent. MgO, without any binding agent, and treated in such a way that it neither contracts nor expands up to the highest temperatures. It possesses a remarkable compactness, mechanical strength and resistance to the action of slags.

But even the best of linings will not stand more than a few weeks if it is not further protected against the cutting action of ordinary slags. As all attempts to repair a cut place of the lining have proved to be of little or no value, the author was led to a very simple solution, especially adaptable to his furnace, by the following consideration.

As all basic slags contain a certain percentage of MgO, which seldom exceeds 10 per cent. and usually runs at about six to seven per cent., the conclusion is justified, that basic slags must saturate themselves to this extent. If, now, such slags are given an opportunity to take up MgO from another source they will not attack the lining. By adding crushed magnesite in such a way that the slag can become saturated before it has been able to attack the lining, this ought to be protected against cutting and should last for a considerable time.

Such an automatic preservation of the lining is much facilitated by the inclination and rotation of the bath which will be more fully described later on. Old magnesite, without any value for other purposes, may be used. It is introduced into the furnace in such a manner as to form a heap M in front of the inner wall, against which it is pressed by the inclination and rotation of the bath as shown in Fig. 3.

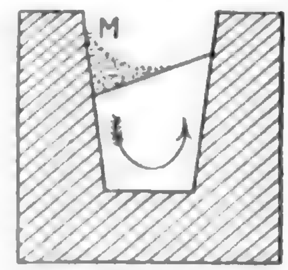


FIG. 3. SECTION THROUGH LINING.

The acid oxides, $SiO_2$ and $P_2O_5$, float on the inclined surface of the bath and meet the heap M, from which they absorb the necessary amount of MgO and CaO before they reach the wall. This method has proved to be most satisfactory, and it has even been found possible to make the inner wall grow by adding too much magnesite, and to cut away the excess by diminishing the percentage of magnesite in the slag.

The lining of the Frick furnace in Essen now attains a life of two to three months regularly, although these furnaces labour under more difficult conditions than furnaces which have to treat molten peroxidised steel.

INCLINATION AND ROTATION OF BATH.—The reciprocal electro-magnetic action of the current in the primary coils and in the bath produces the double effect of making the surface of the bath take an inclined position towards the inner wall, and of causing the whole of the molten metal to revolve in the direction shown by the arrow in Fig. 3. The disadvantage of the inclination, if it is excessive, consists in the greater quantity of slag necessary to cover the metal.

The amount of slag required to cover the bath in the Kjellin furnace will therefore be 4·5 to 5 times that required in the Frick furnace.

In the case of refining liquid steel, when nearly the whole useful work is spent on the melting of slag, a greater

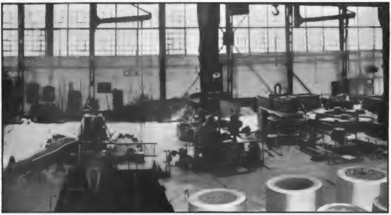


FIG. 4.—GENERAL VIEW OF ELECTRIC PLANT WITH TWO FRICK FURNACES AT KRUPP'S WORKS, ESSEN.

inclination of the bath does not only mean an increased expense for slag materials, but also a corresponding increase in the necessary theoretical energy.

The rotation of the bath is favourable in so far as it secures a great uniformity of the metal and assists in the protection of the lining, and in quickening the reaction between the slag and the metal.

For all these purposes an exceedingly slow rotation of about one revolution per minute would be sufficient, whereas it is generally many times more, and under unfavourable conditions may exceed 100 revolutions per minute.

Too rapid a rotation should be avoided in case the resistance of the lining to abrasion is not particularly great. Further, it is likely that too rapid a rotation may impair the separation of slag emulsions from the steel, therefore every means should be used to keep the rotation down. This is done in the Frick furnace by the

FIG. 5.—ONE OF THE ELECTRIC FURNACES BEING TILTED, KRUPP'S WORKS, ESSEN.

arrangement of the coils, and by using a current of low frequency for the operation of the furnace.

CONCLUSIONS FROM RESULTS OF FURNACES IN ESSEN.—The results of the Frick furnaces in Essen may thus be summarised:

1. The design with a rotable cover has been found most suitable for melting cold stock.

2. The efficiency of the Frick furnace is much higher than that of other induction furnaces and of arc furnaces. Consequently the energy consumption per ton of steel is lower, the annual production is higher, and the cost of production is materially lower than in other furnaces.

3. The method of making the lining and of preventing the cutting by the slag has lengthened the life of the lining up to three months without repair.

4. The inclination and rotation of the bath are sufficient to secure all possible advantages and are at the same time small enough to obviate the necessity of having too much slag to cover the bath.

THE FUTURE OF THE ELECTRIC FURNACE IN THE STEEL INDUSTRY.—It may be said that the future of the electric furnace for steel production will be in the final refining of steel, pre-melted and pre-refined either in a converter or open-hearth furnace, and that its use for melting cold stock, except in places with very cheap water power and high price of fuel, will be restricted to comparatively small quantities of high-class alloy steel, and to the melting of valuable alloys for the addition to ordinary steel, if a saving of alloy can be effected by melting under exclusion of air, as for instance for the melting of ferro-manganese.

TYPES OF FURNACES FOR THE REFINING OF LIQUID STEEL.—The type employed in Essen was designed expressly for melting cold stock, and it is not suitable for any slag treatment or refining, as the difficulties of removing greater amounts of slag through the spout, the only opening at the level of the bath, would be too great. To suit the particular conditions of refining, special types have been designed, the main feature of which is the arrangement of lateral doors, through which the slag can be quickly removed and handled.

The success of the large furnaces in Essen have warranted the building of still larger types, up to 20 tons capacity, as single-ring furnaces; and to meet demands for still larger capacity, double-ring furnaces up to 40 tons have been designed. All furnaces will preferably work with single-phase current, although the double-ring type may also be made to take a two or three-phase current.

Fig. 6 shows the design of single-ring furnaces of 0.3 to 20 tons capacity.

Fig. 7 show the design of double-ring furnaces of 0.6 to 40 tons capacity for single-phase current. The only difference in double-ring furnaces for two or three-phase current consists in

TABLE I.

Single-ring Furnaces for Steel.

| Capacity in tons .. | 0·3 | 0·6 | 1·0 | 1·5 | 2·0 | 3·0 | 5·0 | 7·5 | 10·0 | 12·5 | 15·0 | 20·0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Normal power-consumption, kilowatts .. | 80 | 125 | 180 | 225 | 280 | 375 | 540 | 750 | 950 | 1150 | 1350 | 1750 |
| Normal frequency, cycles per second .. | 50 | 25 | 15 | 12 | 10 | 8 | 6 | 5 | 5 | 5 | 5 | 5 |
| Power factor at normal frequency .. .. | 0·53 | 0·66 | 0.70 | 0·70 | 0·70 | 0·68 | 0·67 | 0·63 | 0·56 | 0·51 | 0·47 | 0·39 |
| Radiation loss at 1,500° C. kilowatts .. | 35 | 54 | 68 | 78 | 90 | 104 | 120 | 140 | 160 | 180 | 200 | 230 |
| Electrical losses, per cent. | 9·0 | 6·5 | 6.2 | 5·7 | 5·0 | 4·7 | 4·2 | 3·3 | 3·2 | 3·0 | 3·0 | 3·1 |
| Maximum efficiency at 1,500° C., per cent. .. | 42 | 47 | 56 | 56 | 59 | 64 | 70 | 75 | 77 | 79 | 79·5 | 81 |
| Efficiency, if stops 25 per cent. of total time, per cent. .. .. | 24 | 30 | 37 | 43 | 46 | 53 | 61 | 67 | 70 | 72 | 73 | 75 |
| Maximum weight of cast, cold charging, tons .. | 0·10 | 0·25 | 0.50 | 0·825 | 1·2 | 1·95 | 3·55 | 5·6 | 7·7 | 9·9 | 12·1 | 16·5 |

the use of two independent iron cores instead of the one common to the two rings formed by the bath as shown for the single-phase double-ring furnace.

Tables I., II., and III. contain general information of a technical nature on single-ring and double-ring furnaces for steel as well as for ferro-manganese.

The tables furnish data concerning the power factor of the different furnaces at a certain normal frequency. The frequency may, however, be chosen to suit local conditions, the power factor or cosinus $\phi$ varying at the same time in such a way as to make tang $\phi$ proportionate to the frequency.

TABLE II.

| | Double-ring Furnaces for Steel. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capacity in tons .. | 0·6 | 1·2 | 2·0 | 3·0 | 4·0 | 6·0 | 10·0 | 15·0 | 20·0 | 25·0 | 30·0 | 40·0 |
| Normal power-consumption, kilowatts .. | 145 | 225 | 320 | 420 | 520 | 690 | 1020 | 1400 | 1800 | 2200 | 2600 | 3100 |
| Normal frequency, cycles per second .. | 50 | 25 | 15 | 12 | 10 | 8 | 6 | 5 | 5 | 5 | 5 | 5 |
| Power factor at normal frequency .. .. | 0·53 | 0·66 | 0·70 | 0·70 | 0·70 | 0·68 | 0·67 | 0·63 | 0·56 | 0·51 | 0.47 | 0·39 |
| Radiation loss at 1,500° C., kilowatts .. | 61 | 91 | 115 | 134 | 152 | 168 | 206 | 238 | 267 | 295 | 321 | 374 |
| Electrical losses, per cent. (single-phase) .. | 7·5 | 5·0 | 6 | 5·5 | 5 | 4·5 | 3·5 | 3 | 3 | 2·7 | 2.5 | 2·5 |
| Electrical losses, per cent. (two-phase) .. .. | 9 | 6 | 7 | 6·5 | 6 | 5 | 4·5 | 3·5 | 3·5 | 3·2 | 2.8 | 3·0 |
| Maximum efficiency at 1,500° C., per cent. (single-phase) .. | 45 | 50 | 57 | 60 | 62 | 68 | 73 | 77 | 79 | 81 | 82 | 83 |
| Maximum efficiency at 1,500° C., per cent., (two-phase) .. .. | 44 | 49 | 53 | 59 | 61 | 67·5 | 72 | 76·5 | 78·5 | 80·5 | 81·7 | 82·5 |
| Efficiency— If stops 25 per cent. of total time, per cent. (single-phase) .. | 28 | 34 | 40 | 47 | 50 | 58 | 64·5 | 70 | 73 | 75 | 76 | 78·5 |
| If stops 25 per cent. of total time, per cent. (two-phase) .. | 27 | 33 | 39 | 46 | 49 | 57·5 | 64 | 69·5 | 72·5 | 74·5 | 75.7 | 78 |

TABLE III.

| | Single-ring Furnaces for Ferro-Manganese. | | | | | | Double-ring Furnaces for Ferro-Manganese. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capacity in tons .. | 0·3 | 0·6 | 1·0 | 1·5 | 2·0 | 3·0 | 0·6 | 1·2 | 2·0 | 3·0 | 4·0 | 5·0 |
| Normal power-consumption, kilowatts .. | 70 | 120 | 170 | 225 | 280 | 390 | 130 | 220 | 320 | 425 | 540 | 750 |
| Power factor at 25 cycles per second .. .. | 0·86 | 0·81 | 0·70 | 0·60 | 0·54 | 0·45 | 0·86 | 0·81 | 0·70 | 0·60 | 0·57 | 0·45 |
| Power factor at 50 cycles per second .. .. | 0·67 | 0·57 | 0·44 | 0·36 | 0·30 | 0·24 | 0·67 | 0·57 | 0·44 | 0·36 | 0·30 | 0·24 |
| Radiation loss at 1,350°, kilowatts .. .. | 29 | 44 | 55 | 64 | 73 | 85 | 50 | 72 | 91 | 106 | 120 | 138 |
| Average electrical losses, per cent. .. .. | 13·0 | 8·5 | 8·0 | 7·7 | 7·6 | 7·2 | 13·0 | 8·5 | 8·2 | 7·9 | 7·7 | 7·3 |
| Efficiency, if stops 4 hours in 24 hours .. | 35 | 43 | 50 | 56 | 59 | 65 | 39 | 47 | 54 | 60 | 63 | 68 |
| Kilogrammes ferro-manganese per hour at full power .. | 100 | 205 | 320 | 450 | 380 | 870 | 200 | 405 | 640 | 900 | 1200 | 1800 |
| Maximum weight of cast, kilogrammes .. | 150 | 350 | 650 | 1050 | 1450 | 2100 | 300 | 700 | 1300 | 2100 | 2900 | 4200 |

ELECTRIC CURRENT AND FREQUENCY.—The induction furnace requires an alternating electric current on account of the wireless transmission of the energy from the primary coils to the secondary bath.

The single-ring furnaces must be supplied with a single-phase current, whereas the double-ring type may be

connected either with a single-phase or if it is provided with double iron-cores, with a two-phase or three-phase system.

As induction furnaces have a very low power factor at the normal frequencies of 25 to 50 cycles, it is only in exceptional cases advisable to connect them directly to existing plants. It will in no case be economically justified to connect furnaces for steel of over 3 tons and for ferro-manganese of over 6 tons capacity to a supply system of 25 cycles. For larger furnaces special dynamos for low frequency should always be provided.

The power factor or cosinus $\phi$ of induction furnaces is always low, because of the low electric resistance of the bath.

According to a formula, developed by the author, the value of tang $\phi$ can be expressed in a comparatively simple way :

$$\text{tang}\ \phi = \frac{\sim}{15950000} \times \frac{1}{R} \times \left(\frac{1}{W_p} + \frac{1}{W_s}\right)$$

$\phi$ = angle of phase difference in between current and voltage

$\sim$ = periodicity or cycles per second.

R = electric resistance of bath in Ohms.

Wp = Magnetic resistance around the primary coils.

Ws = magnetic resistance around the secondary bath.

If the cosinus $\phi$ is known for one periodicity, the approximate value for another periodicity can easily be found

as $\dfrac{\text{tang}\ \phi_1}{\text{tang}\ \phi_2} = \dfrac{\sim_1}{\sim_2}$

For those who are not conversant with electrical matters, it maybe well to indicate that a low power factor has nothing whatsoever to do with the energy consumption, as it only indicates the relation between the real and apparent effect, for which the dynamo has to be designed.

Power factor = cosinus $\phi$ = $\dfrac{\text{kilowatt}}{\text{KVA}}$

The size of the dynamo is fixed by the apparent kilovoltampères or K.V.A. whereas the size of the engine is fixed by the actual power in kilowatts.

The first costs of the power plant for Frick furnaces are lower than those for other furnaces, notwithstanding the higher price of a dynamo, this being due to their higher efficiency.

Load Factor and Uniform Power Consumption.—A great advantage of the induction furnace is the high load factor and the absolute uniformity of the load without shocks or variations. In this respect the induction furnace differs favourably from arc furnaces which even when treating liquid metal give rise to serious short circuits, especially when the metal is boiling as during the oxidation period, making it necessary to reduce the load. The load factor is of no little influence on the production, and thereby on the cost per ton, of steel.

Metallurgical Reactions in the Induction Furnace.—Amongst metallurgists the conviction is general that the induction furnaces are not and cannot be suitable for refining, but only for treating pure stock. This view is based upon the opinion that the first and most important condition for successfully carrying out refining reactions is that the slag should be thin and liquid. In the case of the open-hearth furnace it is certainly correct that a practical refining is not possible without a thin slag. The author is, however, of the opinion, that the thinness of the slag is in this case only of importance for the heat transmission from the hot gases to the bath. If the slag were thick, it would act as an excellent heat insulator, and the bath would cool down. The result of this is that in an open-hearth furnace one is not at liberty to choose the composition of the slag only with a view of obtaining the quickest refining, but must also take into consideration that the slag must be thin enough not to prevent the heat transfer to the surface of contact between metal and slag, at which surface the reactions take place.

Owing to the fact that in an induction furnace the heat is generated in the

steel itself, the temperature of the contact between steel and slag becomes independent of the thinness of the slag, which may be given such a composition as will best ensure the reactions aimed at. As on the other hand the temperature at the contact must be the same in any furnace for the same temperature of the steel, it becomes evident that the induction furnace, far from being a poor refining apparatus in reality offers decided advantages over all other furnaces.

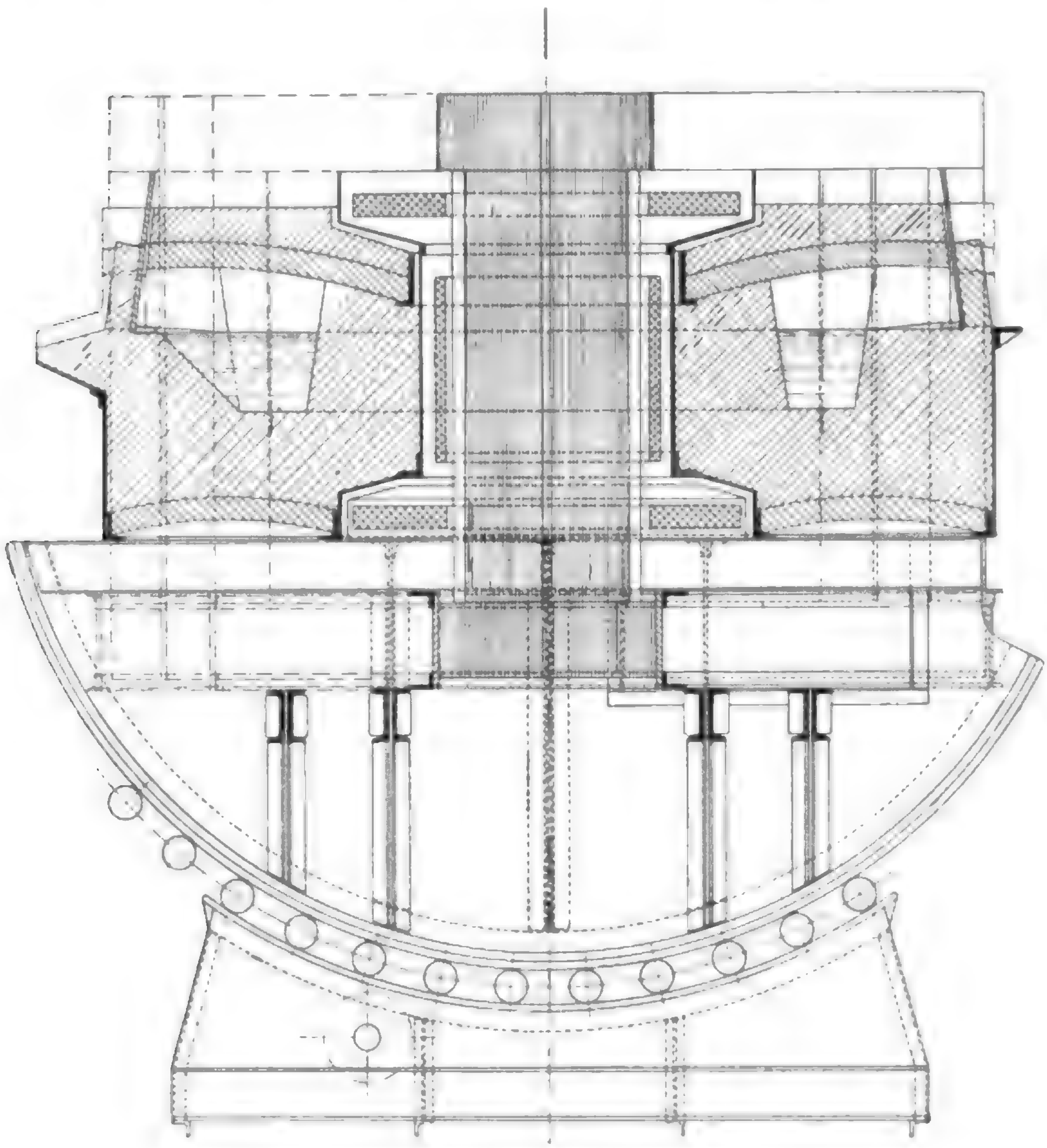


FIG. 6.—CROSS SECTION SINGLE RING SINGLE PHASE ELECTRIC FURNACE.

If the dephosphorisation is first considered this can only take place if the phosphorus in the steel has an opportunity to combine with oxygen in the presence of a slag rich in basic substances, preferably lime, and the reaction will take place so much quicker the richer in lime, and, consequently, the thicker the slag is.

As to the desulphurisation the idea of the importance of a thin liquid slag has apparently been strengthened by the experience with the open-hearth furnace, where it has been found next to impossible to eliminate the sulphur down to any low value. It is, however, to be remembered that the difficulties

in the open-hearth furnace are only based on its character as an oxidising furnace. As long as sulphur is combined with iron or manganese it will be unstable and will travel between steel and slag. To bind it firmly calcium is necessary, but how can it be expected that any calcium should combine with sulphur as long as it has an opportunity to combine with oxygen? The oxidising atmosphere of the open-hearth furnace, and the impossibility of ridding the slag of the oxides of iron and manganese are the true causes why no desulphurisation is possible in the open-hearth furnace.

In an arc furnace it may be of more importance to have a thin slag, as in this type of furnace the heat has to be transmitted through the slag to the metal, but in the induction furnace it is only necessary to have regard to the best slag composition for the elimination of sulphur.

Altogether excellent results with regard to desulphurisation have been obtained in induction furnaces, amongst which those in Dommeldingen might be mentioned, where, according to analyses published in *Stahl und Eisen* of 1911, steel of 0.012 per cent. sulphur to traces, with an average of 0.008 per cent. sulphur has been produced out of a raw material containing about 0.04 per cent. sulphur.

THE DECARBURISATION takes place at the same time as the desiliconising or the dephosphorisation with the aid of scale or pure oil, and does not offer any difficulties. The elimination of 1 kilogramme of carbon requires about 5·25 kilogrammes of ore, and a theoretical energy-consumption of 7 kilowatt-hours to supply the heat required by the reaction, and to melt the ore.

DESILICONISING.—In melting cold stock the silicon in the residue from the previous charge, and also in the materials charged, is oxidised in a very short time by the scale always present on the scrap. If the furnace is charged with liquid metal, the silicon has usually been eliminated in the pre-melting furnace. Should, however, the steel contain any greater amount of silicon, it is advisable to get rid of it by a

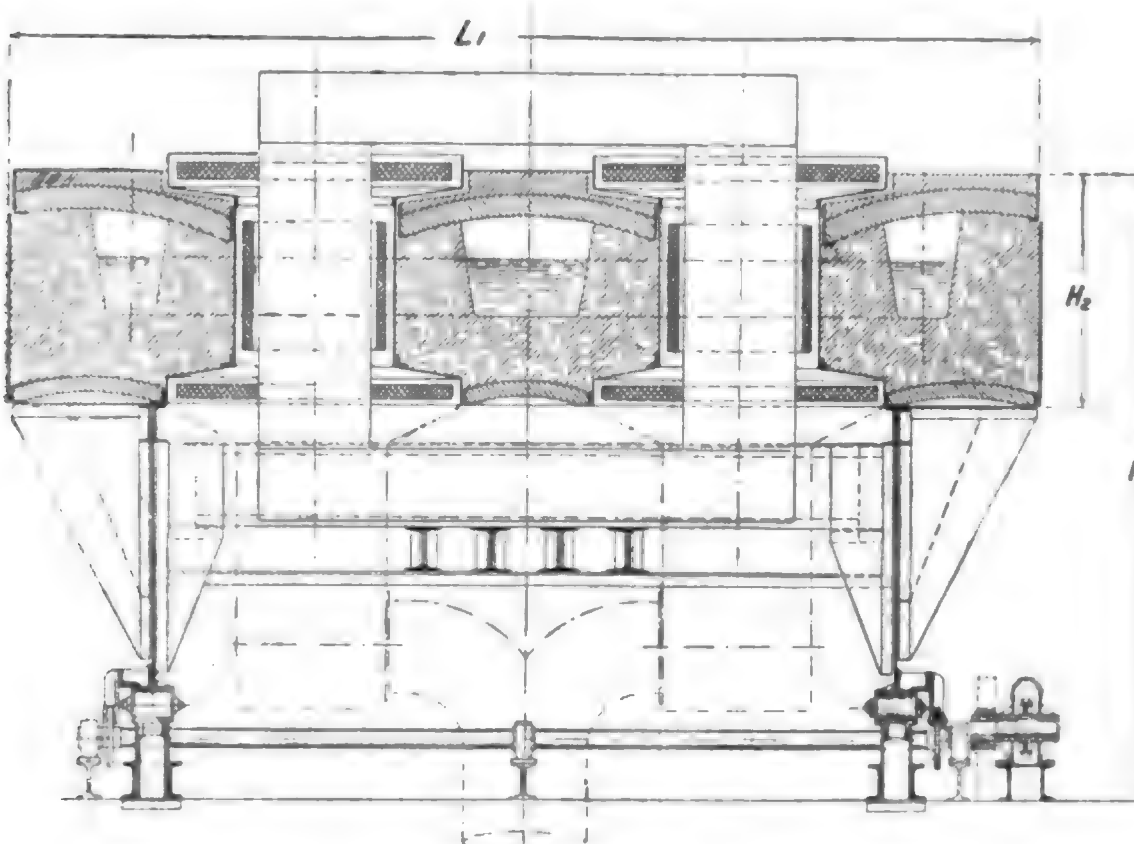



FIG. 7.—LONGITUDINAL SECTION, DOUBLE RING SINGLE PHASE FURNACE.

special slag which may contain up to 28 per cent. of silica, so as to make the amount of slag for the following dephosphorisation as small as possible, and not containing more than 10 per cent. of silica.

DEPHOSPHORISATION.—As the dephosphorisation of steel is an oxidising process, it is only natural to carry it as far as possible in a non-electric furnace. At least when working in combination with a basic open-hearth furnace, arrangements should be made and care be taken that the whole of the phosphorus is eliminated in this furnace, so that the metal when charged into the electric furnace only contains the allowable amount of phosphorus. In this way the operations in the electric furnace are very much simplified, as the slagging, which, especially in large furnaces, is rather hard work requiring much time, is most easily performed during the transfer from the open-hearth into the electric furnace.

The dephosphorisation in the induction furnace is exceedingly simple, quick, and reliable, and is more easily performed than in the arc furnace, in which the strongly reducing character of the arc may cause a re-reduction of the phosphorus from the slag into the steel, if the slag does not contain a sufficient surplus of oxides of iron, or if it is not withdrawn in time. In the induction furnace it is only necessary to provide the required amount of oxygen in the form of scale and of lime to bind the phosphoric acid formed.

Besides the amount of scale necessary for the oxidation of the phosphorus, or about 5 kilogrammes for 1 kilogramme of phosphorus, a surplus of scale has to be added, partly to furnish to the phosphorus abundant opportunity to combine with oxygen, partly to make the slag more easily fusible. This surplus must, however, not be too great, so as not to impair the avidity of the slag to become more fluid by the absorption of $P_2O_5$.

If this is observed, and at the same time the content of silica in the slag is kept as low as possible, the elimination of the phosphorus from the steel takes place very rapidly, and is very much facilitated by the fact that the heat is generated directly in the bath by the electric current passing through it, thus enabling a comparatively thick slag of greatest possible avidity for phosphoric acid to be used.

The degree of freedom from phosphorus in the ultimate product with correct slag treatment depends alone on the care with which the phosphoric slag has been removed. As the removal of the slag, unless it is done by completely emptying the furnace and returning the metal only, requires a great deal of time and hard work, it is preferable not to withdraw all the slag, but in calculating the amount of slag necessary to assume that the phosphorus has to be eliminated to traces. Thus if the content of phosphorus in a steel is to be lowered from 0.06 per cent. to 0.02 per cent., it is sufficient to withdraw two-thirds of the slag. From this consideration the amount of slag for the dephosphorisation should be calculated at 50 *kilogrammes for each kilogramme of phosphorus in the charge* delivered to the furnace.

DEOXIDATION.—After the oxidising reactions and after the removal of the phosphoric slag, it is necessary to eliminate the oxides of iron and manganese in the steel and the slag, before any further refining and alloying can be undertaken. In the induction furnace this deoxidation of steel and slag is preferably carried out by adding ferro-silicon to the metal. In the basic furnace the silicon has a very strong affinity to oxygen, and therefore attacks energetically the easily reduced oxides of iron and manganese, if care is taken not to allow the content of silica in the slag to become too high.

The deoxidation of the dephosphorising slag may be calculated to require :

5·75 kilogs. Si for 1 kilog. P.

For the deoxidation of the FeO and MnO dissolved in the steel there are required :—

0·875 kilogs. Si for 1 kilog. O

For general approximate calculations the steel may be assumed to contain 0·12 per cent. of oxygen or 1.2 kilogramme per ton.

In deoxidation with 50 per cent. ferro-silicon about as much heat is

produced as is necessary to melt the ferro-silicon. Thus the total energy to be supplied for the deoxidation goes to increase the temperature of the rest of the dephosphorising slag—up to the tapping temperature and to melt and superheat up to tapping temperature the slag additions.

For approximate calculations it may be assumed that the weight of the rest of the phosphorus slag to be heated to tapping temperature is 6 kilogrammes, and that the weight of the additions which have to be melted and brought to tapping temperature is 8.25 kilogrammes for 1 ton of steel.

In order to get rid of the last traces of oxygen the use of ferro-silicon alone will not do, but some aluminium or an alloy of aluminium with silicon and iron has to be added.

For approximate calculations the necessary weight of aluminium may be assumed to be 0.2 kilogramme for 1 ton of steel, which would replace about 0·15 kilogramme of silicon or 0·3 kilogramme of 50 per cent. ferro-silicon.

Rephosphorisation.—In treating steel which has been dephosphorised in the electric furnace a reduction of the phosphoric acid left in the slag after dephosphorisation accompanies the deoxidation.

The reduction of 1 kilogramme phosphorus from $P_2O_5$ requires :—

1.13 kilogs. Si for 1 kilog. P.

For approximate calculations an ultimate content of 0·02 per cent. of phosphorus or 0·2 kilogramme phosphorus per ton of steel may be assumed which will require :—

0·45 kilog. FeSi. at 50 per cent. for 1 ton of steel.

2·0 kilogs. slag for 1 ton of steel.

Desulphurisation.—One of the most valuable faculties of the electric furnace is that of eliminating the sulphur down to traces in a quick and efficient manner.

This is due to the neutral or reducing character of the furnace and to the basic lining permitting the use of a slag rich in lime. The exact way in which the elimination of sulphur takes place is hardly yet ascertained. The author's view is that the conditions for a quick removal of the sulphur are analogous to those for dephosphorisation, and that the temperature only plays a subordinate role, the constitution of the slag being the most important factor, and requiring such a composition that the slag will be eager to take up substances which will increase its fluidity.

To make the desulphurisation permanent it is further necessary that the sulphur, contained in the steel as iron sulphide and managanese sulphide, should enter into a combination which will not be dissolvable in the steel. The only such known combination is calcium sulphide = CaS, the formation of which thus has to be aimed at. In the arc furnace the desulphurisation is obtained by carbon according to the following reaction :—

$$CaO + C + FeS = CaS + CO + Fe.$$

It has been said that calcium carbide, $CaC_2$, and not calcium is effective in bringing about the desulphurisation in the arc furnace. This, however, does not seem very probable, there being no apparent reason why lime should be reduced, the oxygen forming CO and the calcium combining with more carbon only to give up the same carbon to other lime, and then itself combining with sulphur. On the other hand, it is evident that the same conditions which favour the formation of $CaC_2$ also allow the elimination of sulphur.

The presence of $CaC_2$ is thus only to be looked upon as a proof of the slag being completely deoxidised and able to absorb sulphur. It is, however, bad economy to try to produce calcium carbide in a steel furnace.

In the induction furnace the desulphurisation is much more quickly effected by ferro-silicon, which in this reaction offers the same advantages as mentioned with regard to deoxidation.

As it is wanted to form calcium sulphide, and as calcium possesses a very strong affinity to oxygen, it is not possible to expect any desulphurisation in this way before the bath and the slag have become deoxidised. Thus, before any sulphur can be removed all the more easily reducible oxides, as phosphoric acid, ferrous and manganese oxides must be reduced. After this has been effected the removal

of sulphur probably takes place in the following manner :—

The desulphurising slag, which mainly consists of lime and fluorspar, must not be allowed during deoxidation to enrich itself too much in $SiO_2$, so as to maintain its tendency to increase further its content of this acid constituent. That tendency is so strong if the steel contains any silicon, that some calcium is even reduced from calcium oxide, the oxygen combining with the silicon, and the calcium robbing the sulphides in the metal of their sulphur, according to the following reaction :—

$$Si + 2CaO + 2FeS + SiO_2 = 2CaS + 2Fe.$$

It is, however, also possible that the fluorspar in the slag to some extent acts as a desulphriser,

$$Si + 2CaFl_2 + 2FeS = SiFl_4 + 2CaS + 2Fe.$$

The silicon fluoride, being a gas, escapes from the furnace.

From experiences with an arc furnace the author has found that even with a perfectly deoxidised white and falling slag it may happen that no elimination of sulphur takes place, or that at any rate it takes place very slowly. In all such cases it was found that the slag was very high in silica through drippings from the roof of silica bricks. The probable explanation is that with too high a percentage of $SiO_2$ the slag has no desire to increase this percentage by giving up some of the oxygen combined with calcium, and the calcium not being liberated it cannot combine with the sulphur.

In the case of an arc furnace the carbon will under certain conditions rather attack $SiO_2$, forming CO and FeSi.

In the case of an induction furnace, the slag, being satisfied with $SiO_2$, will not absorb any further silicon from the bath, and will thus not set any calcium free.

If this be correct the conclusion must be that the desulphurising slag must not contain any too high amount of $SiO_2$.

Analyses of such slags tend to show that the final percentage should not exceed 25 per cent. of $SiO_2$. This has to be kept in mind in preparing the additions for a desulphurising slag, which should mainly consist of lime and fluorspar, the latter added to lower the melting point of the slag and to increase its content of calcium.

By these means the sulphur may be quickly and thoroughly eliminated.

The minimum amount of slag necessary for the absorption of the sulphur cannot yet be definitely determined. It is most likely that with increasing content of CaS the avidity for further CaS is diminished. To be on the safe side the author reckons with a slag of not more than 1.33 per cent. ultimate content of sulphur, or 3 per cent. CaS, corresponding to 75 kilogrammes of slag for 1 kilogramme of sulphur.

On this basis the elimination of 1 kilogramme of sulphur requires :—

0.4375 kilog. Si for 1 kilog. S.

As the desulphurisation takes place under the same slag as the deoxidation and the rephosphorisation the amount of slag necessary for these reactions may be included in the 75 kilogrammes of slag required for 1 kilogramme of sulphur.

RECARBURISING.—The recarburising is preferably effected after the deoxidation, so as to prevent the formation of CO in the steel. If the steel has to contain a high percentage of carbon it is recommended to add the carburiser, charcoal, anthracite, retort-carbon or petrol-coke on the surface of the metal after the ferro-silicon for the deoxidation has been added, but before the bath surface has been covered with the whole of the slag additions, so as to have a clean bath which will readily absorb the carbon.

To get accurate results the furnace should, especially during this period, be kept carefully closed.

For the sake of great accuracy it may sometimes be necessary to recarburise, either by adding high-class pig iron or specially prepared high carbon metal. In recarburising with a metal containing 3.5 per cent. of carbon, 1 kilogramme of carbon, or 0.1 per cent. per ton of steel, requires 28.6 kilogrammes of such metal, involving an energy expenditure of 12 kilowatt hours for melting.

ALLOYING.—On account of the possibility of completely deoxidising both metal and slag, the electric furnace is

eminently suitable for the manufacture of all kinds of alloyed steels, as it will not only save the losses of metal, occurring in other furnaces, but also greatly facilitate the obtaining of correct analyses. Through the gentle rotation of the bath in the Frick furnace a perfect distribution of the alloys and an absolute uniformity of the product can be secured. The alloys are added to the metal after the bath has become deoxidised, shortly before tapping.

ENERGY-CONSUMPTION AND EFFICIENCY.—The electric energy supplied to an electric furnace is spent in :—

1. Electrical losses.
2. Radiation losses.
3. Various losses, as through open doors, &c.
4. Theoretical or useful energy-consumption, spent in melting and heating to the tapping temperature of metal, alloys and slag.

By a careful study of these different items on which the energy has to be spent, it is possible to make exact calculations in advance with regard to any process which may be desired to be carried out in the electric furnace.

ELECTRIC LOSSES. — The electric losses in percentages of the nominal power in kilowatts absorbed are given in the Tables I., II. and III. They vary between 6 and 2.5 per cent. in steel furnaces of 1 to 40 tons capacity, and between 8 and 7.2 per cent. in furnaces for ferro-manganese of 1 to 6 tons capacity.

RADIATION LOSSES—After deduction of the electric losses the whole of the energy supplied to the furnace is transmitted into the metal and spent as heat. In most metallurgical, not electric, furnaces the heat carried away by the gases is so great that the radiation losses become of less importance. This is partly the reason why no care is taken to heat-insulate such furnaces. On the other hand, the source of heat, coal, is comparatively cheap. In electric steel furnaces, from which only very little gas escapes and which use a much more expensive source of heat the radiation losses become of the greatest importance, well worthy of careful consideration.

As the heat conductivity of refractory materials increases with the absolute temperature, and the difference of temperature between the bath and the outside of the furnace very nearly increases with the temperature of the bath, the radiation loss at different temperatures will very nearly vary as the square of the temperature.

In calculations it has to be remembered that the radiation losses go on a long as the furnace is hot, whether it is standing idle, between the heats or over Sundays, or working, whereas the electrical losses only occur while the current is on, and that the average temperature in the furnaces varies with different methods of operation, casting temperature, etc.

VARIOUS LOSSES.—Besides the above mentioned radiation losses, the losses due to direct radiation while the doors are open have to be considered. Such losses will be considerably less in an induction furnace than in arc furnaces, in which the enormously high temperatures in the arc exist above the slag.

Further, the losses which consist in the heat carried away with gases and fumes from the furnace may have to be considered. In arc furnaces with their enormous temperatures t ese losses are not insignificant. In the induction furnace they can be kept sufficiently low to be negligible, if care be taken to keep the furnace tight.

THEORETICAL ENERGY-CONSUMPTION —Under theoretical energy-consumption the whole of the useful work done in the furnace is to be understood, or the difference between the energy contained in the materials leaving the furnace and the energy contained in the materials charged into the furnace. This useful work consists in :—

Melting and superheating of the steel or ferro-manganese charged ; melting and superheating of the alloys ; melting and superheating of the slag ; providing the necessary heat required for the chemical reactions taking place in the furnace. The energy required for these reactions is, however, small and is mostly compensated by the heat gained by the combustion of Si. resp. other metals.

The only reaction requiring any appreciable amount of heat is the

decarburisation, which, however, is generally small, and mainly occurs in melting cold stock when some of the carbon is lost through oxidation by the scale.

The following figures, which are based on theoretical studies, and have been tested in practice, are sufficiently exact to allow the calculation of the theoretical energy necessary for any process in the steel manufacture for which the electric furnace may be wanted. For the sake of simplicity all energies have been expressed in kilowatt-hours at 857 kilogramme-calories.

| | |
|---|---|
| Total energy in 1,000 kilogrammes of steel at 1400° C. . .. | = 330 kw.-hrs. |
| Energy necessary to raise the temperature of 1,000 kilogrammes molten steel by 1° C. | = 0·4 ,, |
| Average total energy in 1,000 kilogrammes of molten slag at 1400° C., taking into account the heat of formation of the slag .. .. .. .. .. | = 500 ,, |
| Energy necessary to raise the temperature of 1,000 kilogrammes molten slag by 1° C... | = 0·6 ,, |
| Energy to expel the carbonic acid from 1,000 kilogrammes of limestone, not including the heat necessary to raise the temperature of the lime or the carbonic acid .. .. .. | = 500 ,, |
| Energy to decarburise 1 kilogramme carbon or 0·1 per cent. from 1,000 kilogrammes steel, including melting and heating of the ore necessary .. .. | = 7 ,, |

The energy for melting and superheating the alloys can be assumed to be the same as that for steel. The alloys used in deoxidation, rephosphorisation, and desulphurisation, as FeSi, AlSiFe, and the like, do not require any electric energy for melting and heating, as their combustion provides sufficient heat for this purpose.

For approximate calculations the following figures may be used :—

In melting cold stock without any refining, with 0.15 per cent. Si in the materials charged and 2.1 kilogrammes FeSi at 50 per cent. for deoxidation ; 14 kilogrammes of slag per ton of charge.

For dephosphorisation, assuming a slag with 2 per cent. P or 4.58 per cent. $P_2O_2$ ; 50 kilogrammes of slag per 1 kilogramme P in material charged.

For the desulphurising and deoxidising slag not less than 75 kilogrammes of slag per 1 kilogramme S to be eliminated.

The increase of temperature which has to be produced in the electric furnace depends on the tapping temperature and, with liquid charge, on the temperature at which the charge has been delivered to the electric furnace.

Table A gives good average ta p ng temperatur s :—

As a rule the temperature of the steel from the converter, or from the open-hearth furnace, is as high, and sometimes higher, than the tapping temperature from the electric furnace.

The following figures for the theoretical energy consumption under various conditions should be of value.

For melting cold stock, including the slag se tabl B :—

The theoretical energy consumption with cold stock varies thus between 310 and 460 kilowatt-hours per ton as steel, as against only 20 to 65 kilowatt-hours when hot metal is charged, or say seven to twenty times more in the first case than the second.

EFFICIENCY.—The Tables I., II., and III. show the difference in the

**A**

| | | | |
|---|---|---|---|
| Tapping temperature of | 80 per cent. ferro-manganese | = | 1350° C. |
| ,, ,, | 12 per cent. manganese steel | = | 1450° C. |
| ,, ,, | high carbon steel . . . | = | 1530°-1580° C. |
| ,, ,, | low-carbon steel and for special alloyed steel and steel for steel castings . . . | = | 1580°-1680° C. |

**B**

| | | |
|---|---|---|
| 80 per cent. Ferromanganese | : 310 | kw. hours per ton at 1350° C. tapping temperature. |
| 12 per cent. Manganese steel | : 360 | ,, ,, ,, 1750° C. ,, ,, |
| High carbon steel . | : 410 | ,, ,, ,, 1500° C. ,, ,, |
| Alloyed and soft steel . | : 435 | ,, ,, ,, 1625° C. ,, ,, |
| Very hot steel . . | : 460 | ,, ,, ,, 1680° C. ,, ,, |

For refining liquid steel from P. and S., inclusive the melting of the cold alloys :

| | |
|---|---|
| 12 per cent. manganese steel .. .. .. .. | 30 to 50 kw. hours per ton, if temperature of metal charged is 1550 to 1600° C. |
| Normal steel, without any increase of temperature in the electric furnace | 20 to 55 kw. hours per ton, according to degree of refining. |
| Normal steel, with 50° C. increase of temperature in the electric furnace | 40 to 65 kw. hours per ton, according to degree of refining. |

efficiency of the various furnaces:—

| | Single-ring Furnaces | | | Double-ring Furnaces. | | |
|---|---|---|---|---|---|---|
| Capacity in tons .. | 0·3 | 5·0 | 20·0 | 0·6 | 10·0 | 40·0 |
| Maximum efficiency per cent. .. .. | 42 | 70 | 81 | 45 | 73 | 83 |
| Efficiency, if stoppages = 25 per cent. of time .. | 24 | 61 | 75 | 28 | 64·5 | 78·5 |

**Duration of Heats, Daily Production, and Practical Energy-consumption.**—These depend on so many different factors, as theoretical energy-consumption, duration of stoppages, average temperature of furnace, and tapping temperature, that a complete table for all conditions would become too cumbersome.

For approximate calculations the Tables (I., II., and III.) furnish sufficient information to find the practical energy-consumption by dividing the assumed or calculated theoretical energy-consumption by the efficiency of the furnace, given in the tables, and then to find the daily production.

To obtain more accurate results, more elaborate calculations are necessary.

Table IV. shows such calculations for five different cases. The examples chosen give some interesting results, worth noting.

## Various Combinations of Electric Furnaces with Open-hearth Furnaces or Converters.

In considering the combinations of the electric furnace with premelting furnaces, the aim should be to make such dispositions as to utilise the specific advantages of the different furnaces as fully as possible.

Therefore all oxidising reactions should, as far as possible, be carried out in the oxidising furnace, and the electric furnace should mainly be used for desulphurisation, deoxidation, and alloying; or for such reactions which require a reducing or neutral atmosphere. The electric furnace may also with great advantage be used for raising the temperature of the steel from that necessary for the oxidising reactions, up to tapping temperature. This is especially the case when the electric furnace is operating in combination with an open-hearth furnace. The efficiency of the electric furnace is not very much influenced by the temperature of the metal. A 20-ton single-ring furnace has, for instance, a maximum efficiency of 81 per cent. at 1,500° C. and of 78·8 per cent. at 1,600 ° C., thus a very small reduction.

In an open-hearth furnace the conditions are very different, because of the fact that the useful heat has to be transferred from the gases to the steel. The temperature of the gases is fairly constant during the whole charge. As long as the stock is cold the amount of heat absorbed from the gases is considerable and the efficiency $= \dfrac{\text{absorbed heat}}{\text{total heat in gases}}$ is comparatively good. With increasing temperature of the steel the transfer of heat becomes less, and finally becomes nil, when the difference of temperature between the gases and the steel has become so low as to allow only so much heat to be transmitted as is necessary to cover the radiation losses from the bottom of the furnace. At this stage the efficiency of the furnace is 0. This question of the efficiency of the open-hearth furnace is of considerable importance for the appreciation of the possibilities of the electric furnace, but so far as the author knows, no complete study of the open-hearth furnace with regard to its efficiency during various stages has ever been published.

In Fig. 8 the curves represent the case of an open-hearth furnace working on cold stock, each heat taking eight hours, compared with an electric furnace, supplied from a gas-power plant, taking over some part of the work from the O-H furnace towards the end of the heat.

The curve giving the value of the efficiency of the open-hearth furnace during the heat falls from 50·3 per cent. at the start, when the charge is cold, to 5·6 per cent. when the metal has become hot, a value which is less than one-third of the average efficiency, 20·4 per cent. The curve showing the average efficiency from

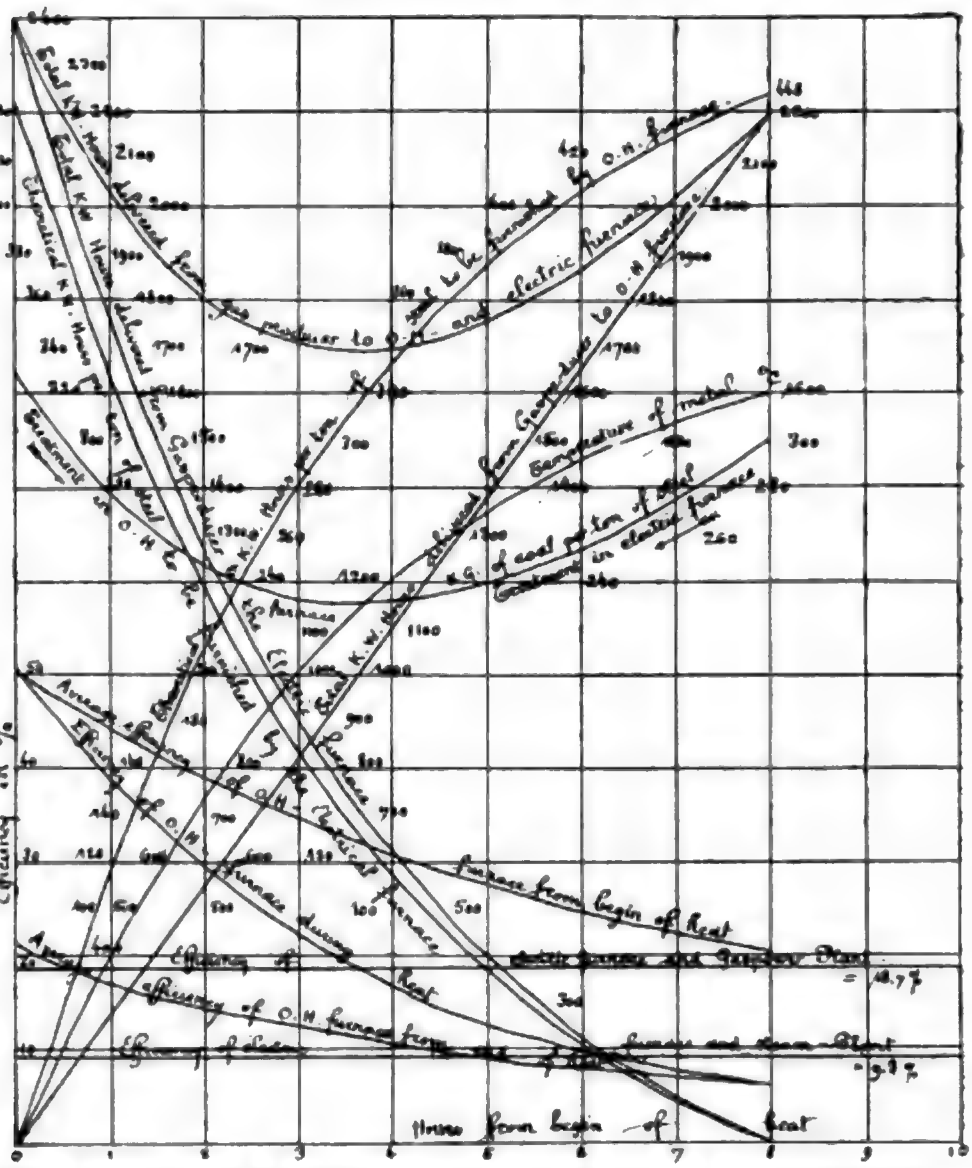



FIG. 8.—COMBINATION OF OPEN HEARTH AND ELECTRIC FURNACE EFFICIENCY CURVES.

beginning of heat drops from 50·3 per cent. to 20·4 per cent.—that is, by shortening the time of the treatment in the open-hearth furnace, the average efficiency can be raised.

Now turning to find the total efficiency of an electric furnace plant, using the same producer-gas as the open-hearth furnace, the following figures give a fairly correct result for a large well-designed plant :—

| | Gas Power. | Steam. |
|---|---|---|
| | Per Cent. | Per Cent. |
| Efficiency of boilers .. | .. | 80·0 |
| „ „ engines .. | 26·0 | 16·0 |
| „ „ dynamo .. | 90·0 | 90·0 |
| „ „ electric furnace during heat | 80·0 | 80·0 |
| Total efficiency of power plant and electric furnace .. .. .. | 18·7 | 9·3 |

These figures show that the total efficiency of the electric furnace plant is higher than the efficiency of the open-hearth furnace towards the end of a heat. From the diagram it will be found that the lines representing the efficiency of the electric furnace for gas power and steam respectively, cut those representing the efficiency of the open-hearth furnace, and that the efficiency of the electric furnace plant exceeds that of the open-hearth furnace after 3.5 hours in the case of gas power and after 6.2 hours in the case of steam.

As gas-power in the case of electric furnaces with a very high average load-factor always will be preferable, this case will especially be considered.

Another curve in Fig. 8 gives the

total coal-consumption per ton of steel. If the operation could be so arranged as to keep the steel in the open-hearth furnace for only 3·5 hours, the lowest coal-consumption of 230 kilogrammes per ton, or 23 per cent., would result, thus a saving of coal of 23·4 per cent. on the coal-consumption in case the whole treatment is carried out in the open-hearth furnace, where 300 kilogrammes would be necessary.

TABLE IV.—CALCULATION OF TIME FOR ONE HEAT, PRACTICAL ENERGY—CONSUMPTION PER TON, HEATS IN 24 HOURS, DAILY PRODUCTION, EFFICIENCY.

| | | | | | | |
|---|---|---|---|---|---|---|
| $Z_1$ | Kind of charge | Fe-Mn 80% | Cold Stock. | Liquid metal. | Liquid metal. | Liquid metal. |
| $Z_2$ | Type of furnace | D. R. | S. R. | S. R. | S. R. | D. R. |
| $Z_3$ | Capacity of furnace, tons | 3 | 10 | 15 | 15 | 25 |
| $Z_4$ | Weight of cast, tons, = G | 2·1 | 7·7 | 15 | 15 | 25 |
| $Z_5$ | Nominal power in kilowatt = N | 425 | 950 | 1350 | 1350 | 2200 |
| $Z_6$ | Required power in kilowatt = K | 425 | to be calculated | 1350 | 1350 | to be calculated. |
| $Z_7$ | Theoretical energy-consumption = E Kw-hours per ton | 310 | 440 | 40 | 60 | 65 |
| $Z_8$ | Radiation loss through furnace walls at $1500^2$ = S kw. | 134 | 160 | 200 | 200 | 295 |
| $Z_9$ | Charging temperature, °C | 0 | 0 | 1600° | 1600° | 1550 |
| $Z_{10}$ | Casting temperature, °C | 1350° | 1650° | 1600° | 1600° | 1600° |
| $Z_{11}$ | Average temperature of bath = t | 1350° | 1500° | 1600° | 1580° | 1575° |
| $Z_{12}$ | Radiation loss through walls at $t^2 = \frac{t^2}{1500^2}$ .S kw. | 108 | 160 | 227·5 | 221 | 324 |
| $Z_{13}$ | ″ ″ ″ doors per heat = s kw. hours | 10 | 25·1 | 47 | 47 | 92·4 |
| $Z_{14}$ | s = 2 + 3 G for S. R and s = 2.4 + 3.6 G for D. R. furnaces | | | | | |
| $Z_{15}$ | Electrical losses in parts of "K" = e | ·08 | .032 | ·03 | ·03 | ·032 |
| $Z_{16}$ | Duration of stops during and after each heat = z hours | 30' = ·5H | 10' = ·167H | 20' = ·333H | 15' = ·25H | 30' = ·5H |
| $Z_{17}$ | Time for one heat = Z hours | to be calculated | 5 | to be calculated | to be calculated. | 1·5 |
| $Z_{18}$ | $Z \times \frac{t^2}{1500^2} \times S = Z_{17} \times Z_{12}$ | ″ | 800 | ″ | ″ | 486 |
| $Z_{19}$ | $1 - e$ = electrical efficiency = $1 - Z_{15}$ | 0·92 | 0·968 | 0·97 | 0·97 | 0.968 |
| $Z_{20}$ | $K \times (1 - e) = Z_6 \times Z_{19}$ | 391 | to be calculated | 1310·5 | 1310·5 | to be calculated |
| $Z_{21}$ | $K \times (1 - e) - \frac{t^2}{1500^2} \times S = Z_{20} - Z_{12}$ | 283 | ″ | 1083 | 1089·5 | ″ |
| $Z_{22}$ | $E \times G = Z_7 \times Z_4$ | 651 | 3388 | 600 | 900 | 1625 |
| $Z_{23}$ | $E \times G + s = Z_{22} + Z_{13}$ | 661 | 3413 | 647 | 947 | 1718 |
| $Z_{24}$ | $K \times (1 - e) \times z = Z_{20} \times Z_{16}$ | 195·5 | to be calculated | 437 | 328 | to be calculated |
| $Z_{25}$ | $E G + s + K \times (1 - e) \times z = Z_{23} + Z_{24}$ | 856·5 | ″ | 1084 | 1275 | ″ |
| $Z_{26}$ | Time for one heat = $Z = \frac{E \times G + s + K \times (1-e) \times z}{K \times (1-e) - \frac{t^2}{1500^2} .S} = \frac{Z_{25}}{Z_{21}}$ | 3·025 | | 1.0 | 1·072 | |
| $Z_{27}$ | $E \times G + s + \frac{t^2}{1500^2} .S = Z_{23} + Z_{18}$ | — | 4213 | | | 2042 |
| $Z_{28}$ | $Z - z = Z_{17} - Z_{16}$ respectively $Z_{26} - Z_{16}$ | 2·525 | 4·833 | 0·667 | 0·922 | 1·0 |
| $Z_{29}$ | $(Z - z) \times (1 - e) = Z_{28} \times Z_{19}$ | | 4·68 | | | 0·968 |
| $Z_{30}$ | Required power in kilowatt = $K = \frac{E \times G + s + \frac{t^2}{1500^2} S}{(Z-z) \times (1-e)} = \frac{Z_{27}}{Z_{29}}$ | | 901 | | | 2110 |
| $Z_{31}$ | Kw-hours per heat = $K \times (Z-z) = Z_6 \times Z_{28}$ respectively $= Z_{30} \times Z_{28}$ | 1072 | 4350 | 900 | 1245 | 2110 |
| $Z_{32}$ | Practical kw-hours per ton = $F = \frac{K \times (Z-z)}{G} = \frac{Z_{31}}{Z_4}$ | 510 | 565 | 60 | 83 | 84.4 |
| $Z_{33}$ | Number of heats in 24 hours = $C = 24/Z = \frac{24}{Z_{17}}$ resp. $\frac{24}{Z_{26}}$ | 7·94 | 4.8 | 24 | 20.47 | 16 |
| $Z_{34}$ | Production in 24 hours = $P = C \times G = Z_{33} \times Z_4$, tons | 16·68 | 36·9 | 360 | 307.5 | 400 |
| $Z_{35}$ | Efficiency of furnace = $\frac{E}{F} = n = \frac{Z_7}{Z_{32}}$ | 0·608 | 0·779 | 0·667 | 0·723 | 0·77 |
| $Z_{36}$ | ″ ″ ″ in % = 100, n = 100 $Z_{35}$ | 60·8 | 77·9 | 66·7 | 72·3 | 77. |
| | Influence of stops over Sundays. | | | | | |
| $Z_{37}$ | Approximate hours of stops over Sundays | 24 | 24 | 30 | 24 | 24 |
| $Z_{38}$ | ″ ″ of operation in one week | 144 | 144 | 138 | 144 | 144 |
| $Z_{39}$ | Number of heats in one week = $\frac{Z_{38}}{Z_{17}}$ resp. $\frac{Z_{38}}{Z_{26}}$ | 47 | 28 | 138 | 123 | 96 |
| $Z_{40}$ | Production in tons in one week = $Z_4 \times Z_{39}$ | 98·7 | 215·6 | 2070 | 1845 | 2400 |
| $Z_{41}$ | Exact hours of operation in 1 week = $Z_{39} \times Z_{17} - Z_{39} \times Z_{26}$ | 142 | 140 | 138 | 144 | 144 |
| $Z_{42}$ | ″ ″ ″ stops over Sunday = $168 - Z_{41}$ | 26 | 28 | 30 | 24 | 24 |
| $Z_{43}$ | Kw-hours to keep furnace hot over Sunday = $S.Z_{42}$ resp. $\frac{1350^2}{1500^2} . S\ Z_{42}$ | 2810 | 4480 | 6000 | 4800 | 7080 |
| $Z_{44}$ | Kw.hours for heat during one week = $Z_{31} \times Z_{39}$ | 50400 | 121800 | 124200 | 153300 | 202500 |
| $Z_{45}$ | Total kw-hours in one week = $Z_{43} + Z_{44}$ | 53510 | 126280 | 130200 | 158·100 | 209·580 |
| $Z_{46}$ | ″ ″ per ton of steel = $\frac{Z_{45}}{Z_{40}}$ | 542 | 587 | 62·8 | 85·7 | 87·2 |
| $Z_{47}$ | Efficiency of furnace in % = $\frac{Z_7}{Z_{46}} \cdot 100$ | 57·25 | 75 | 63·7 | 70 | 74·5 |

Although the electric furnace undoubtedly will come into extensive use in combination with open-hearth furnaces, its importance will, however, be much greater to the present Bessemer acid and basic processes. In districts rich in ores suitable for acid or basic working, it is probable that the open-hearth furnace will soon totally disappear, as the electric steel then can be produced at a price equal to or less than that of open-hearth steel, and of higher quality. The difference in cost of production between Bessemer acid or basic steel and open-hearth steel may be said to vary between 6s. and 12s. per ton. The electric treatment in the induction furnace costs from 5s. to 8s., or possibly 10s. per ton, according to the amount of refining wanted, the size of the plant, etc., thus showing that the electric steel can be produced at a lower cost than the O-H steel.

FERRO-MANGANESE.—In discussing the future of the electric furnace in the steel industry, its use for the melting of ferro-manganese, to be added to steel from the open-hearth furnace or from the converter, ought to be mentioned.

The advantages of using liquid instead of cold ferro-manganese are mainly: quicker and more reliable deoxidation, greater uniformity of the

TABLE V.—CALCULATION OF COST OF PRODUCTION.

| | | | | | | |
|---|---|---|---|---|---|---|
| $Z_1$ | Kind of charge | 80 per cent. Fe. Mn. | Cold Stock. | Liquid Metal. | Liquid Metal. | Liquid Metal. |
| $Z_2$ | Type of furnace | D. R. | S. R. | S. R. | S. R. | D. R. |
| $Z_3$ | Capacity of furnace, tons | 3 | 10 | 15 | 15 | 25 |
| $Z_4$ | Greatest weight of cast, tons | 2·1 | 7·7 | 15 | 15 | 25 |
| $Z_5$ | Power-consumption, kilowatts | 425 | 900 | 1350 | 1350 | 2110 |
| $Z_6$ | Time for one heat, hours | 3·025 | 5·0 | 1·0 | 1·172 | 1·5 |
| $Z_7$ | Stops per heat, hours | 0·5 | 0·167 | 0·333 | 0·25 | 0·5 |
| $Z_8$ | Theoretical energy-consumption, kilowatt-hours per ton | 310 | 440 | 40 | 60 | 65 |
| $Z_9$ | Practical energy-consumption, kilowatt-hours per ton, including current for Sunday | 542 | 587 | 63 | 86 | 88 |
| $Z_{10}$ | Production in 24 hours, tons | 16·7 | 36·9 | 360 | 307·5 | 400 |
| $Z_{11}$ | Production in 1 week, tons | 98·7 | 215·6 | 2070 | 1845 | 2400 |
| $Z_{12}$ | Production in 40 weeks, tons | 3950 | 8600 | 82,800 | 74,000 | 96,000 |
| $Z_{13}$ | Power of fan for cooling coils, Kilowatts | 4.5 | 9·5 | 11·0 | 11·0 | 17·0 |
| $Z_{14}$ | Kilowatt-hours for fan per ton of steel = $\frac{Z_{13} \times Z_6}{Z_4}$ | 3·5 | 6·5 | 0·8 | 0·9 | 1·1 |
| $Z_{15}$ | Kind of lining | Frick. | Frick. | Tar-Dolomit. | Frick. | Tar-Magnesit. |
| $Z_{16}$ | Cost of lining, including current for heating, shillings | 1800 | 3800 | 2700 | 4500 | 5500 |
| $Z_{17}$ | Production on one lining, tons | 1180 | 1290 | 4140 | 11,050 | 9,600 |
| $Z_{18}$ | Weight of slag-additions, kilogrammes per ton of steel | .. | 14 | 55 | 80 | 65 |
| $Z_{19}$ | Weight of FeSi for deoxidation, rephosphorisation, and desulphurisation, kilogrammes per ton of steel | .. | 2·0 | 4·8 | 4·9 | 4·8 |
| $Z_{20}$ | Weight of aluminium for final deoxidation, kilogrammes per ton of steel | .. | 0·2 | 0·2 | 0·2 | 0·2 |
| $Z_{21}$ | Price of current, shillings per kilowatt-hour | 0.03 | 0·04 | 0·02 | 0·02 | 0·02 |
| | *Cost of production per ton of steel:—* | | | | | |
| $Z_{22}$ | Cost of current for the furnace, shillings | 16·26 | 23·48 | 1·26 | 1·72 | 1.76 |
| $Z_{23}$ | Cost of lining, shillings | 1·53 | 2·95 | 0·66 | 0·41 | 0·58 |
| $Z_{24}$ | Cost of current for fan, shillings | 0.11 | 0·26 | 0·02 | 0·02 | 0·02 |
| | Cost of slag-additions at 25 shillings per ton, shillings | .. | 0·35 | 1·37 | 2·00 | 1·62 |
| | Cost of deoxidizers at 220 shillings per ton Fe Si, and at 1,400 shillings per ton aluminium, shillings | .. | 0·72 | 1·34 | 1·36 | 1·34 |
| | Cost of labour, crane, analysis, and management, shillings | ca. 1·50 | 4·00 | 1·33 | 1·33 | 0·95 |
| | Cost of ladle, tools and sundries | ca. 4·0 | 0·74 | 0·68 | 0·68 | 0·58 |
| | Total operating costs, shillings | 23·40 | 32·50 | 6·66 | 7·52 | 6·85 |
| | Cost of interest, upkeep, and depreciation of furnace and building with crane, shillings | ca. 4·50 | 3·10 | 0·45 | 0·50 | 0·60 |
| | Total cost of production per ton, shillings | 28 | 35·60 | 7·11 | 8·02 | 7·45 |
| | Or | 28 | 35/7 | 7/1½ | 8/- | 7/5½ |

*Remark.*—The costs of raw materials and alloys are not included, nor the royalty.

composition of the steel, avoidance of hard spots in the ingots due to undissolved FeMn, and thus higher quality, greater security that all FeMn is absorbed by the steel, and thus less loss, which in the case of FeMn in pieces may become considerable through some of it getting stuck in the slag. The advantage of the electric furnace for the melting of ferro-manganese over other furnaces is again based on its non-oxidising atmosphere, thus avoiding loss of metal.

Comparing the induction furnace with the arc furnace for the melting of ferro-manganese, the advantages of the former type are still more evident than in the case of steel melting. The high temperature of the arc becomes even more disadvantageous on account of the greater volatility of the manganese. The advantage of the shape of the bath of the arc-furnace, allowing a repair of the slag line between the heats in the same manner as with the open-hearth furnace, becomes negligible, as no slag is wanted, and thus no cutting of the lining occurs. The induction furnace for ferro-manganese has a further advantage over those for steel, namely, the power factor is higher, not only on account of the higher electric resistance of the FeMn, but also on account of the much smaller capacity of the furnaces for a certain daily output, due to the small casts required. The power factor is in fact sufficiently high to warrant the connection of furnaces for ferro-manganese to existing power-plants of 25 or 50 cycles (see Table IV.).

The melting costs vary between 20s. and 30s. per ton, or between 10 and 15 per cent. of the value of the FeMn. Experience with liquid FeMn demonstrates that a saving of 20 to 40 per cent. can be made compared with cold addition. By premelting the FeMn in the electric furnace, not only an improvement of the quality of the steel, but also a saving in cost may be gained varying between 5 and 30 per cent. of the value of FeMn, say 10s. to 60s. per ton of FeMn.

Cost of Production.—To enter upon an exhaustive discussion of the costs of the electric steel, would require more space than is available. With a view, however, of conveying an idea of the amounts involved in melting or treating steel in an up-to-date induction furnace, Table V. has been prepared, in which the costs have been calculated for a number of characteristic cases.

# THE DEVELOPMENT OF REVOLVING GRATE GAS PRODUCERS IN GERMANY

By Dipl. Ing. Gwosdz

THE chief requirements of a good gas producer are the following: The delivery of a gas of high calorific power, the most complete combustion of the fuel, and the largest possible capacity. Further, labour should be reduced to a minimum and there should be little wear and tear on the working parts. The heating value of a gas, which is produced without a great addition of steam to the air necessary for gasification depends to a large extent on its content of CO. Although at the very beginning Ebelmen succeeded in getting with his producer of the blast furnace type a gas of almost ideal composition, many scientific experiments and much practical experience were necessary, before any reliable data as to the essential conditions for the formation of CO in a producer was arrived at. In the first place the original idea that the formation of CO was the result of the incomplete and slow combustion, which follows from the supply of too little air, was abandoned, and it was recognised that a high temperature in the zone of gasification was in the highest degree favourable to the formation of CO. Practical experience showed that a high fuel-bed is necessary, for the results of scientific experiments proved that in order to convert the $CO_2$, which is at first formed in the producer into CO, a longer or shorter period of contact with the glowing fuel is necessary according to the height of temperature. Further it was recognised that the duration of contact of gases depends to a large extent on the physical nature of the fuel, as well as on its retention in the hot zone of the producer. The chief difficulties of gasification, which in theory appears so simple, result from the content of ashes, which is natural to every solid fuel to a greater or lesser degree. At high temperatures the ashes of many fuels begin to melt and form clinkers, which cause too empty spaces or become attached to the side of the producer, so that a good distribution of the air over the cross section of the shaft is prevented and a certain part of the fuel is useless for the formation of gas and the remainder is blown through too rapidly by the gases. In order to remedy this undesirable state of affairs it was necessary in the old producers to poke the fire zone constantly and clean the grate of clinkers. Moreover, a smaller amount of air was used and consequently the cross section of the shaft was not fully utilised. Fuels with a higher percentage of easily fusible ash could only be gasified with the addition of a very large amount of steam, the result of which was bad burning out of the ash. The frequent raking of the fuel round the grate caused a break in the supply of air, and a reduction in the production of gas. Thus in order to obtain accessibility to the fire zone the producers were constructed with rather small cross section.

These, in short, are the reasons why the old construction did not fulfil the requirements of a good producer, and they sufficiently explain the fact, that for several decades after the advantages of gas firing over direct heating with fuel were recognised, in many plants where gas firing was possible, the latter method remained unchanged. It was only recently that a considerable change took place in this matter, namely by the Morgan

producer, which made continuous working possible together with increased capacity and less attention. Similar producers were soon put on the market in Germany specially by Poetter and Schmidt and Desgraz. These producers, which were constructed with an inner shaft diameter of 2 to 2·5 m., gasified 6 to 10 t. of mineral coal per 24 hours. The failure of the grate was characteristic of all these constructions, as the fuel lay in a pan filled with water, into which the lower part of the shaft dipped. Owing to the water seal being so constructed, the ashes could be raked out without interruption of the producer working. The air was generally supplied through a central grate, rising up into the shaft from the water-pan, on account of the larger shaft-diameter.

These producers, which after a short time were extensively adopted, because they were introduced at a time when iron works in Germany were being unusually extended, and because in many cases they were replacing older installations, had nevertheless the fault that the ashes had to be discharged by hand. It seemed, however, that mechanical ash discharge would be suitable for producers of large capacity, not only because of the economy of substituting the machine for manual labour, but by securing a more uniform process of gasification. Intermittent rake ash-discharging causes shifting of the fuel-bed, which results in a certain amount of disturbance to the hot zone necessary for a good production of gas. This disturbance was eliminated or was much reduced as soon as a continuous ash removal, corresponding in quantity to the amount of coal burned, was effected.

A continuous mechanical discharge of ash was made possible about seven years ago by A. von Kerpely with his revolving grate producer. In this the ash pan, on which the fuel-bed rests, is made to revolve so that the ash is piled up on a sloping-plate, fitting into it and is pushed over the edge of the pan. The grate, which is tower shaped, rests on the ash pan, in order to secure a good distribution of the air over the whole of the cross section of the fire zone, and the ash discharge and poking necessary to every producer were made easier and the capacity considerably increased. Thus in revolving grate producers of from 2 to 3 m. shaft diameter, 15 to 25 tons of mineral coal or up to 30 tons of brown coal could be gasified per 24 hours. Even with low grade coal results were obtained, which in the old producers could not be reached even when working with the best fuels. The success of the revolving grate producer were caused by a further development of gas firing. In many iron-works, a central installation was adopted for gas heating, not only for the heating and melting furnace, but also for the steam-boilers and retorts. There is no doubt that we have not yet reached the end of this development, and efforts are being directed especially towards enabling the producer to work economically on fuels of the lowest grade.

The revolving grate producer was first employed for the gasification of brown coal. Fig. 1 is a cross section through a revolving grate producer specially made for brown coal and mineral coal of low quality. The jacket "a" is supported on the foundations by three or four columns. Into the shaft projects the grate "b," which is built on the ash-pan "c," and revolves with it. The ashpan contains water and is provided with a water-seal "g" "h," so that the air and gas inside the producer are shut off from the outer-air. The ash-pan connected with the grate rests on a ball-race "d" and has a toothed-wheel round the circumference. The bottom part of the producer is slowly revolved by means of the worm "e" and the driving mechanism "f." A scraper "i" is fitted into the pan and during the revolution it piles up the ashes and pushes them over the edge of the pan, whence by means of the slide "k" they are taken to a truck. The air and steam are supplied through the chamber "l" under the grate. The top of the shaft is closed with a cover-plate, fitted with raking and sight-holes and which carry the feed-

hopper "n." The gas-outlet "o" is in the upper part of the jacket. The high water-jacket and low grate are characteristic of this producer for brown coal. According to the trials made by the Gesellschaft für Gasfeuerungs-Tecknik of Dresden, who possess the rights for the Kerpely patents, this high water-jacket has proved to be very important for the gasification of brown coal.

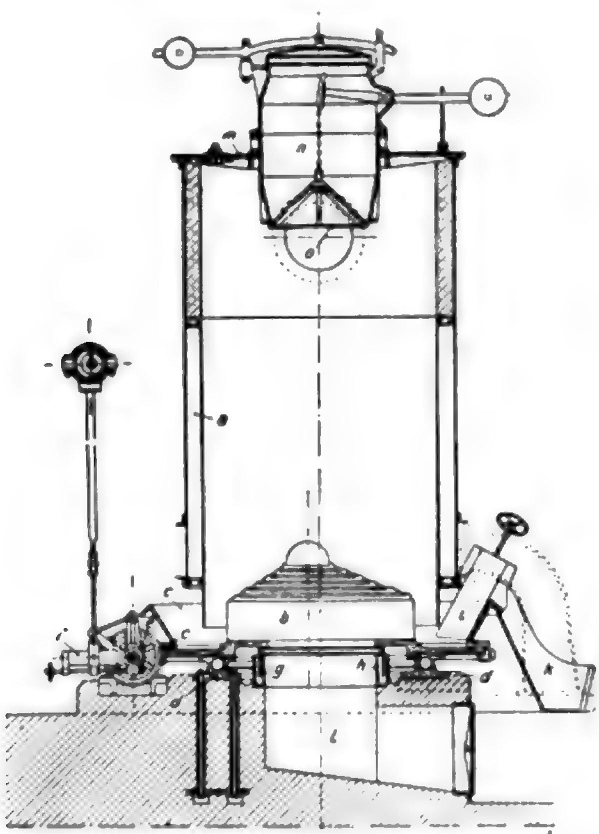


FIG. 1.—KERPELY GAS PRODUCER FOR GASIFYING BROWN COAL.

The object of employing a water cooled jacket instead of the brick lined shaft usual with the old producers, was to prevent the clinkers from fastening on the sides of the shaft. This result is ascribed to the lowering of temperature which, owing to the continuous cooling of the jacket, takes place in the hot zone near the sides of the shaft. Too much cooling, however, with certain fuels has an unfavourable effect on the production of gas. It has been found, for instance, that for mineral coal a considerably shorter water-jacket (Fig. 2) must be adopted, because mineral-coal requires a higher temperature for distillation than brown-coal. Should the temperature of the gasification zone be too low owing to the cooling effect of the water-jacket, the distillation of the coal only partly takes place in the hot zone and a gas rich in $CO_2$ is produced. Subsequent manufacturers of revolving grate producers have in many cases replaced the water-jacket by brick work. Another plan, which

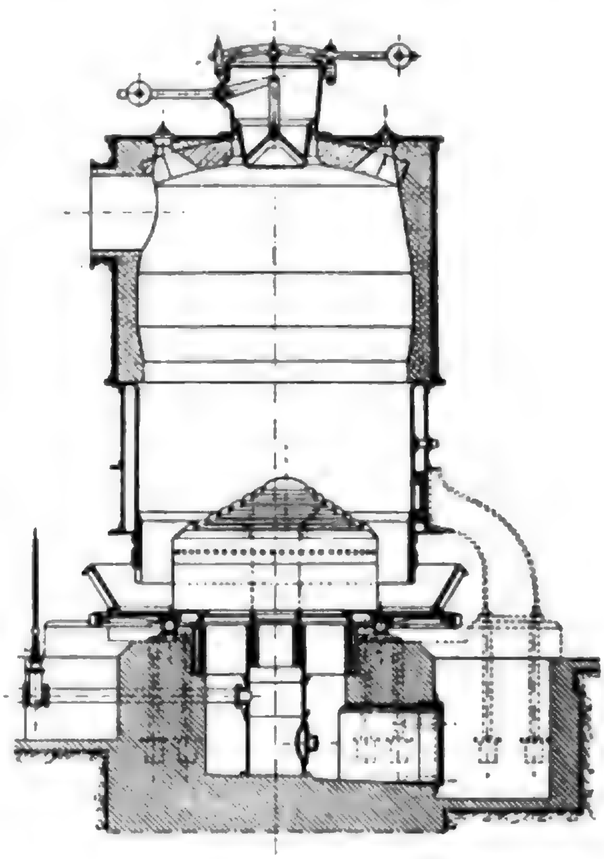


FIG. 2.—KERPELY REVOLVING GRATE PRODUCER FOR GASIFYING LIGNITE.

has also answered well in Kerpely producers for gasifying crude coal, containing a high percentage of dust—which must not be cooled rapidly from the outside—consists in retaining the water-jacket, but covering it with a lining of firebrick on the inner side. Fig. 3 shows an outer shell constructed in this manner. The suitability of a high water-jacket for most sorts of brown coal is explained by the following circumstances. As brown-coal is more easily gasified than mineral coal, in a revolving grate producer of equal cross section considerably more of the former will be gasified in the same

time than of the latter. In consequence of the greater swiftness of the air and gas streams, the hottest zone will extend further towards the top and necessitate the sides being cooled up to a higher point. On the other hand, the conversion of $CO_2$ to CO is not greatly impaired by the cooling of the jacket because, owing to the greater

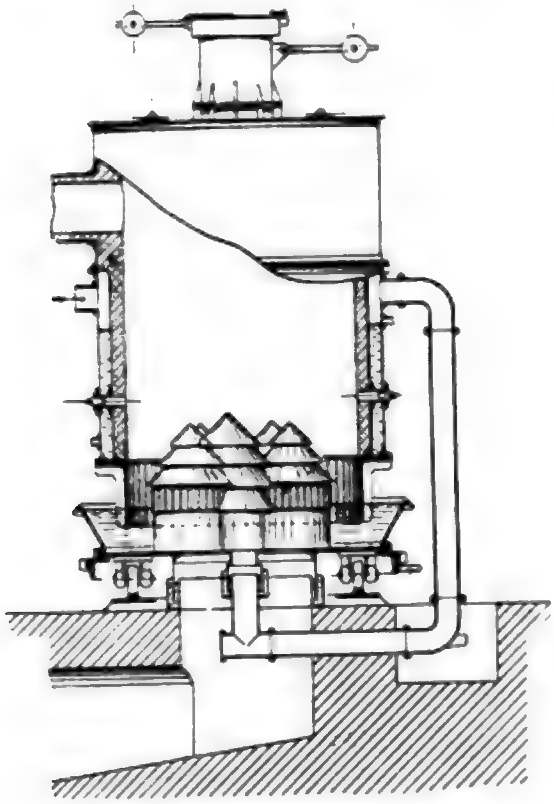


FIG. 3.—REHMANN GAS PRODUCER.

extension of the conversion, it remains in contact with the glowing carbon for a longer time.

As is well known, fuels poor in gas, such as anthracite and coke, are gasified with an addition of more steam than for mineral coal. These fuels, as is natural, can bear more cooling from outside. If the gasification of coke is effected with a small supply of steam, a considerable amount of heat can be transmitted to the cooling water. Mr. Marischka, the chief-engineer of the Vienna gas works, has, following out this idea, recently designed a revolving grate producer, the shaft of which is constructed as a steam-boiler. (Fig. 4.) This producer, which has already been tried with great success, promises to attain considerable importance, especially for those gas installations which, instead of separately firing the retorts, have adopted central heating. The boiler is of such a construction that it is possible to make extensive use of the free sensible heat of the passing gases. The combination of boiler and producer had often been proposed before, but their practical working seems only to have become possible with the employment of the revolving grate producer, which permits of a greater consumption of fuel and therefore a greater development of heat in a shaft of given cross section.

Another very important detail of the revolving grate producer is the body of the grate. This, since the introduction of the Kerpely producer, has experienced many transformations. The adoption of the producer to German

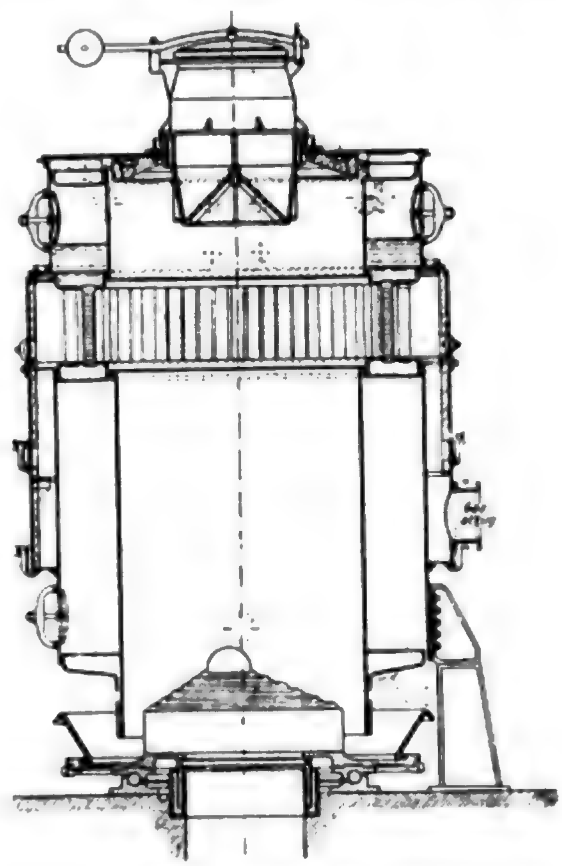


FIG. 4.—MARISCHKA COMBINED GAS PRODUCER AND STEAM BOILER.

mineral coal took place first, later the body of the grate was made higher and of harder material (cast-steel). More recently it has been constructed together with the lower division of the inner air chamber as shown in Fig. 2. This lower division in producers of

large diameter has proved useful, as it facilitates an equal regulation of the fire over the entire cross section. It makes it possible to supply to the different zones of the column of fuel more or less steam and inversely less or more air and has proved specially useful for the gasification of crude coal and other fuels rich in dust, with which the charge always lies deeper in the centre than on the outside. Besides the Gesellschaft für Gasfeuerungs-Technik of Dresden, the works of Thyssen at Mühlheim and Ehrhardt and Sehmer at Saarbrücken deserve special mention for the construction of these producers.

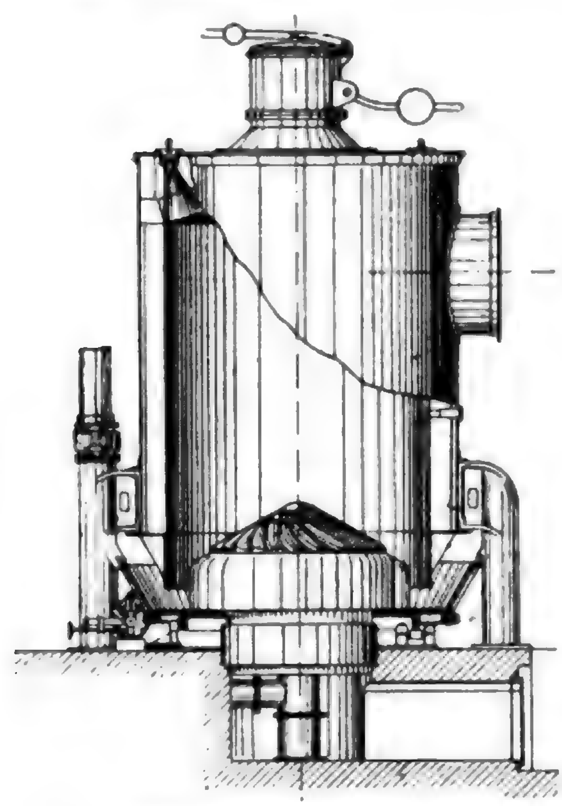


FIG. 5.—DEUTSCHE HÜTTENBAUGESELLSCHAFT REVOLVING PRODUCER.

The later forms of construction of revolving grate gas producers, of which quite a number have already appeared on the market, differ from the Kerpely producer chiefly in the construction of the grate. The object has been to improve this in regard to its two main actions, namely, the poking of the column of fuel and the distribution of air over the cross section. Thus, among others, came into existence the well-known producers of Rehmann (see Fig. 3) and Hilger, which were very successful. Recently the Deutsche Hüttenbaugesellschaft in Düsseldorf have come forward with a revolving grate producer based on the idea that the equal distribution of air is attained by means of the lowest possible air pressure. It is, however, important that this equal distribution should be continuously maintained, and that the slits in the grate should not get stopped up. As shown in Fig. 5 the upper part of the grate consists of super-imposed fan-shaped plates which overlap in a direction opposite to that of revolution of the grate. Thus wedge-shaped channels, which are wider below than at the top, are formed, consequently that part of the column of fuel further from the centre of the shaft is also supplied with the requisite amount of air. In contra-distinction to the earlier constructions, no great stress is laid upon the poking effect of the body of the grate itself. This is placed centrally, and has round its circumference several interchangeable projections or ash chambers which catch the ashes in different parts of the shaft and in this way effect a regular lowering of the fuel bed. The following are the results of a test with coal of 8.35% ash content and 7,269 calories:—

| | |
|---|---|
| Gasification capacity per 24 hours .................. | 24 tons |
| Combustible residue in the ashes from 100 parts of the given fuel .............. | 0,23% |
| Average steam pressure of injector .................. | 0,91 Atm. |
| Average temperature of steam in super heater .... | 232° C |
| Average temperature of steam in producer........ | 210° C |
| Average air pressure ...... | 163 mm. W.G. |
| „ gas pressure ...... | 72 mm W.G. |
| „ steam content of gas | 20.1 g./m³ |

Average composition of gas:

| | | | |
|---|---|---|---|
| $CO_2$ | .. | 4.2% | by vol. |
| $O_2$ | .. | 0.0 | „ |
| $CO$ | .. | 26.1 | „ |
| $H_2$ | .. | 11.7 | „ |
| $CH_4$ | .. | 3.6 | „ |
| $CH_y$ | .. | 0.3 | „ |
| $N_2$ | .. | 55.1 | „ by difference |
| S | .. | 100,0% | by vol. |

Calorific value: 1,384 calories.m³.

In contrast with this method of construction the object of which is merely to effect an equal distribution

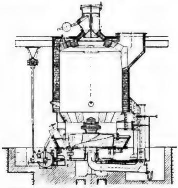


FIG. 6.—HUTH AND ROTTGER REVOLVING GRATE GAS PRODUCER.

of air, in other revolving grate producers, great importance is attached to a strong poking of the fuel bed. In this connection the revolving grate producer of de Fontaine, of Hannover, may be noted. The upper part of the grate is made up of a number of segments of circles, which act as crushing plates and working in conjunction with a worm, which is cut round the bottom part of the shaft, grind up any clinkers. A similar effect is assured by the revolving grate shown in Fig. 6, constructed by Hüth and Roettger, of Dortmund. This combination possesses a central blast nozzle and a annular wind box surrounding the base portion of the producer immediately below its wall. The producer of Küppers also belongs to this class. In this the body of the grate and the shaft possess knife-shaped edges, which press into the fuel; grate and shaft are rotated in opposite direction. This producer is well known to possess an extraordinarily high capacity, nevertheless, the simultaneous rotation of shaft and grate has as yet been little imitated. The same can be said of the so-called "Pilgrim step movement" of the grate, which is employed in the

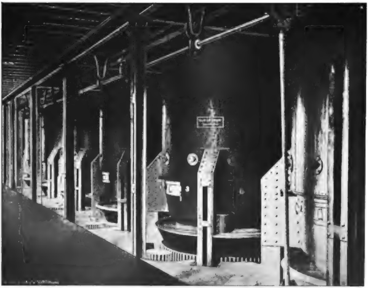


FIG. 7.—VIEW OF A SET OF 6 HUTH AND ROTTGER GAS PRODUCERS WITH REVOLVING GRATES.

Hilger producer, made by Poetters. This movement of the ash pan has the advantage that the fuel bed can be kept in motion independently of the quantity of ashes that has to be discharged. Similar ideas were pursued in those constructions in which the grate has a rotative movement independent of the ash pan. As to the practical success of this kind of grate construction, compared with the revolving ash pan with grate fixed to it, there are as yet no particulars to hand. Mention must also be made here of the efforts to carry up the raking effect of the grate tower to the higher parts of the shaft by means of projections fixed to the grate. These arrangements working in the hot zone, even if it were an easy matter to water-cool them, would be subject to great wear and tear. Such cooling can be better carried out in producers in which the raking arrangements are led in through the cover plate of the shaft. In this case the stirrers generally serve only to rake the coking zone when gasifying caking fuel.

Every improvement in gas heating means a more economical use of the natural fuel supplies available to us. Steel works engineers, whom we have to thank for the first producers constructed, have for 70 years been earnestly emphasising the necessity for such economy. Among others, Bischoff and Ebelmen hoped to obtain, by means of the development of gas firing, a means of making the utmost possible use of the enormous amount of low grade fuels, the combustion of which till then was uneconomical. But beginnings of much promise were followed by a period of standstill, which only by recent successes has been transformed into progress.

Also the attempts to gasify in the revolving grate producer inferior kinds of brown-coal and even the washing and sortings from the preparation of fine coal, appear possible from results already obtained. The most important achievement of the revolving grate producer in recent times is in any case its adaptability to fine grain fuels, such as coal-and coke-dust, which are difficult to gasify and often form the refuse of mines, steel, gas, and railway works. As has been stated the revolving grate producer has been applied to the consumption of crude coal with high dust content with the greatest success, and the author had the opportunity of seeing at an iron-works in the neighbourhood of the Saar, an installation of 12 producers at work, in which a gas of not more than 1-2 per cent. by volume of $CO_2$ and having a calorific value of from 1200-1300 calories, was obtained from mineral coal, which cost 9 marks per ton at the mine, while the price of ordinary so-called gas coal was 15 marks per ton. The ashes seemed to be well burnt out.

The suction gas plants made by the firm of Julius Pintsch, Berlin, for fine grain fuels such as fine anthracite, coke breeze, firebox dust have been well known for the last five years. These plants which have been provided for a number of railways in Prussia and other German states for gasifying the dust drawn from the locomotive fire boxes, consist of step-grate gas-producers. The step-grate gas-producer was formerly considered suitable chiefly for the gasification of fuels of fine grain, because it is easier in it to maintain automatically a low and even depth of fuel-bed. These step-grate gas-producers must in any case be cleaned by hand, owing to the high percentage of ash in fine grain fuels, which makes the working more expensive. On account of the low depth of the fuel bed with which these producers work a gas rich in $CO_2$ is delivered which is suitable for gas engines, but not for some kinds of heating purposes.

One of the firms which have gasified fine grain fuels with success in a producer with mechanical ash-discharge is the Maschinenfabrik Augsburg-Nürnberg. The Nürnberg gas-producer for fine grain fuel has a diameter of 2 to 3 m. and is about 3 m. high. The lower part of the bricklining of the shaft is constructed with water-cooling. The ash pan possesses the usual water-seal and carries a step-formed grate-top. The ash pan is not continually revolved, but from time to time by means of a worm-gear, thus discharging the ashes from the producer. For producing the

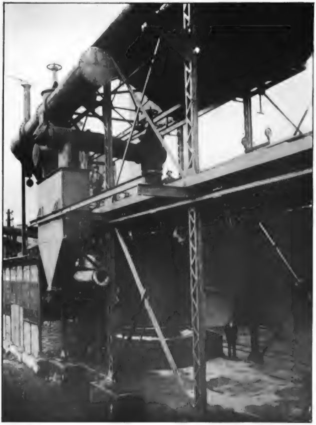


FIG. 8. VIEW OF A KERPELY HIGH PRESSURE GAS INSTALLATION.

air for gasification a suction-fan, placed behind the washer, is used. In order to overcome more easily the resistance of the proportionately high bed of fuel, it has been found useful to assist the suction fan by means of a steam-blower, placed in the air-main leading to the grate. A number of such producers are working successfully in the gas works of Berlin and Munich. As the produced gas is used for driving gas-engines, the producers are in connection with cleaning plants, in which the gas is completely freed from tar and dust. According to the statement of the firm, 0.55 0.7 kg. of coke breeze are necessary to produce 1 H.P. hour. Owing to the cost of the cleaning plant this type is only suitable for large installations, *i.e.*, those of at least 200 H.P. upwards. Trials which were made with the Nürnberg small coal gas producer at the "Consolidation III./IV." mine have shown, that from coke ash or from a mixture of 2/3 coke-ash and 1/3 pea-coke, a gas having a calorific value of 1,000 to 1,100 calories was obtained, its composition being from 10 to 12

per cent. $CO_2$ by vol., 16-20 per cent. CO, and 17-19 per cent. $H_2$. From the high content of hydrogen in the gas it must be inferred that the gasification was effected with the supply of a considerable amount of steam, and that, therefore, a large part of the steam passed through the producer without being decomposed. On cleaning in the washer, the steam is chiefly condensed. For direct employment in smelting furnaces, *i.e.*, making use of its sensible heat, a gas containing a greater amount of steam would not be suitable.

Kerpely himself has recently produced a new type of the revolving grate producer, which is known as the "high pressure producer," and renders possible the gasification of fine grain fuels without the addition of a larger steam supply. The characteristic of this construction is the possibility of an unusually high air-pressure—from 400 to 700 mm. W.G.—when gasifying, by means of which a distribution of air reaching over the whole cross section of the producer and a uniformly rapid gasification is accomplished. On account of the high air-pressure it is practicable to maintain a greater height of fuel-bed than formerly appeared possible when gasifying fuels of fine grain. This producer (see Fig. 7) possesses a shaft in the lower part of which a water-jacket is constructed. The fire-brick lining as it goes upwards is at first considerably reduced in diameter, and then widens out again into a gas collecting space measuring about 1.8 m. diameter at the top. This naturally facilitates the separation from the stream of gas the portions of fuel carried away by it. At the bottom the shaft is closed with the usual revolving ash pan with eccentric tower grate.

The top part of the grate is pierced not by slits, but by a great number of fine holes, which break up the air into numerous fine streams, so that it is distributed over the whole mass of fine fuel. The ash pan possesses no water-seal, because the water would be blown out of it owing to the high-pressure. Instead of having a water-seal, the whole of the bottom part of the producer is enclosed by an air-tight iron casing, and is connected only at the point of ash-discharge with a reservoir out of which the ashes are emptied at intervals

| Diameter of Producer. | | 2000 mm. | | | | | |
|---|---|---|---|---|---|---|---|
| Kind of Fuel. | | Coke-ash. | Coke-ash. | Coal-dust from Ohemgrube. | Styrian Brown Coal. | Bosnian Fine Coal. | ½ Coke-ash. ½ Coal-dust. |
| Content of Carbon in— | | | | | | | |
| Fuel | wt.% | 63.0 | 67.78 | 60.97 | 40.61 | 37.09 | 65.1 |
| Water | " | 11.0 | 17.0 | 9.25 | 20.30 | 33.0 | 11.4 |
| Ash | " | 20.5 | 12.0 | 14.60 | 11.40 | 14.0 | 12.4 |
| Size of grain mm.— | | | | | | | |
| 0.0.5 | " | 3.0 | 11.0 | 4.1 | 1.4 | 5.0 | 14.0 |
| 0.5-1 | " | 4.0 | 9.0 | 7.0 | 2.3 | 1.9 | 14.0 |
| 1-3 | " | 21.0 | 20.0 | 30.4 | 43.3 | 25.0 | 15.0 |
| 3-5 | " | 24.0 | 21.0 | 20.1 | 28.0 | 21.0 | 26.0 |
| 5-8 | " | 28.0 | 18.0 | 23.9 | 21.4 | 26.6 | 12.0 |
| 8-12 | " | 16.0 | 12.0 | 10.1 | 1.8 | 14.5 | 7.0 |
| Over 12 | " | 4.0 | 9.0 | 4.4 | 1.8 | 5.0 | 9.0 |
| Period of trial | hrs. | 72.0 | 41.0 | 36.5 | 96.0 | 80.0 | 96.0 |
| Total capacity | kg. | 27000 | 14434 | 14720 | 31660 | 34545 | 38428 |
| Capacity per m². hr. | " | 118 | 108 | 128 | 101 | 130 | 123 |
| Composition of gas:— | | | | | | | |
| $CO_2$ | % by vol. | 3.0 | 2.4 | 5.18 | 10.0 | 7.0 | 4.1 |
| CO | " | 30.2 | 32.5 | 26.66 | 21.9 | 27.1 | 29.5 |
| H | " | 14.85 | 12.3 | 15.01 | 22.2 | 18.3 | 14.5 |
| $CH_4$ | " | 0.1 | — | 1.9 | 2.0 | 2.5 | 1.4 |
| Carbon in the tar and dust in 1 cbm. of gas | gr. | 3.5 | 6.4 | 7.4 | 25.5 | 19.6 | 5.8 |
| Carbon content of the ash | wt. % | 25.0 | 35.0 | 15.5 | 12.2 | 18.1 | 33.0 |
| Loss of carbon in ash per kg. fuel | gr. | 68.0 | 65.0 | 26.65 | 16.0 | 31.0 | 53.0 |
| Amount of gas from 1 kg. fuel | cbm. | 3.05 | 3.17 | 3.1 | 2.3 | 1.36 | 3.1 |
| Calorific value of 1 kg. fuel | cal. | 5300 | 5618 | 5650 | 4520 | 5255 | 5470 |
| Calorific value of 1 cbm. gas | cal. | 1332 | 1304 | 1356 | 1408 | 1517 | 1390 |
| Thermal efficiency | % | 76.5 | 73.6 | 74.5 | 72.5 | 72.0 | 78.7 |
| Fuel utilised | " | 89.2 | 90.5 | 95.5 | 97.0 | 92.0 | 90.3 |
| Steam used per 100 kg. fuel | kg. | 15—18 | | | | | |

by the opening of a bell-stopper. Already different kinds of inferior fuels have been dealt with in the high pressure producer with much success. From the foregoing table, for which the author has to thank the Gesellschaft für Gasfeuerungs-Technik, it appears that the performance of the producer with regard to the calorific value of the gas as well as to the complete combustion of the fuel, is scarcely surpassed by a producer working with good mineral coal.

The introduction of the revolving grate producer certainly represents a considerable advance in gas production practice, and the further development of this system will have to be directed towards dealing with the difficulties arising from a high percentage of ash, and securing an economical combustion of inferior fuels especially those of fine grain.

# THE PANAMA CANAL

ITS COMMERCIAL AND ECONOMIC SIGNIFICANCE.

By John Stuart, B.A (Oxon).

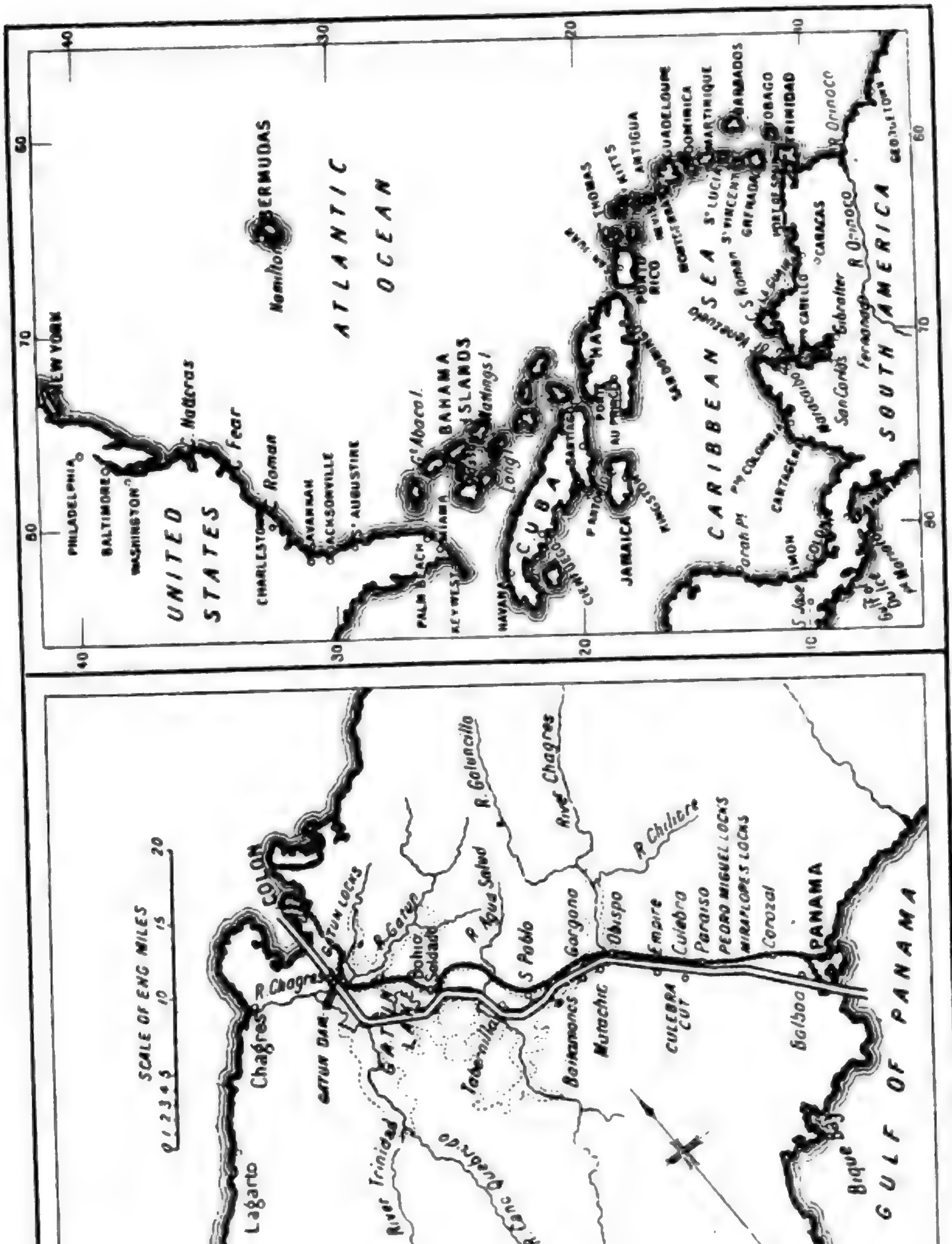
*(Reprinted from The South American Year Book.)*

THE economic consequences of the opening of the canal will be far reaching and will affect to a greater or lesser degree nearly every country in the world, from the Republic of Panama itself to the Eastern shores of the North Atlantic and the Western shores of the Pacific. In the first place it will aid materially in fostering economic progress in the State of Panama through which it passes, and will lessen the economic stagnation and political instability of many adjoining states in Central and South America, along the Pacific Coast.

The Republic of Panama is in the enviable position, from a peace point of view, of being a State without an army, and yet one which is more assured of peace than any of the other Central of South American republics. Its military weakness is a political necessity, like the weakness of Roumania and Holland, at the mouths of the Danube and Rhine. The political interests of the great commercial nations demand that important commercial waterways like the Panama Canal, the Danube and the Rhine should be contiguous to, or held, by powers which are too weak to tie them up. The absence of a Panamanian army and the existence of an ample canal zone are the best guarantees of the independence of the Panama Republic. Had this State not been detached from the Colombian federation, the fate of the latter haggling and turbulent republic would have been sealed as effectually as was that of Egypt when the working of the Suez Canal passed into the hands of the British Government.

The opening of the canal will inaugurate the construction of high roads and railways which has hitherto been held in check by the ease and cheapness of coastwise and river travel. We find the same backwardness of railway construction in countries like Colombia and Nicaragua, which have considerable river communication, as contrasted with States like Costa Rica, Guatemala, and Mexico, where there is a comparative poverty of water communication. The new Panama railways will run along or near the Pacific Coast where the bulk of the population is located, though even here it is very scanty.

The opening of the canal is destined also to change fundamentally the




MAPS SHOWING PANAMA CANAL AND WEST INDIES.
Reproduced from South American Year Book.

communications of Western Europe as well as the Eastern seaboard of the United States with the Western coast of the whole American Continent from Vancouver as far south as Valparaiso unless the traffic through the canal is interfered with by prohibitive tolls. It will revolutionise the conditions of trade and intercourse between the eastern and western states of the whole American continent; between Pennsylvania and California as well as between Chile and the Argentine. The portion of the United States coast which will benefit most by the opening of the canal will probably be the Gulf coast, the products of whose hinterland, both industrial and agricultural, will be diverted from their present outlets on the New York and Chesapeake bays to seek markets on the eastern and western coasts of the Pacific. Behind the Gulf ports of Mobile and New Orleans lies a dense population, largely industrial, eager to consume tropical produce, and at the same time anxious to find a market for their industrial products in Pacific ports.

The opening of the canal will shift several of the great trade routes of the world. It will shorten by one-half or more the sea distance from all north Atlantic ports to the Pacific ports of America. The distance between New York and the western Pacific sea-board north of Panama will be shortened by 8,415 miles, and the distance between New York and the Pacific ports south of Panama will be shortened by 5,000 miles. It will bring the Atlantic coast of the United States nearer to Australia and Japan than is any northern European port. Liverpool is now 1,142 miles nearer to Australian harbours than is New York, but after the canal is opened it will be 2,382 miles further off than New York, a difference of 3,524 miles. Hence in the competition for Australian markets New York will have a good start over any ports of England, France, or Germany. Further, New York, Boston, and Philadelphia will be placed on even terms with Liverpool, London, and Hamburg in relation to sea distance from all the coast of China between Hongkong and Tientsin. West of Hongkong, however, the Suez Canal will be shorter to the Orient for both European and American ports of the North Atlantic.

It now remains to consider the effect which the Panama Canal will have on the economic development and commercial relations of Latin America. Trustworthy authorities tell us that the population of Spanish America did not in the year 1900 exceed that of the Spanish Colonies a hundred years before. When we think of the enormous possibilities of the rich alluvial plains, the tropical forests, the extensive pastoral uplands and the vast abundance of its precious metals, we might well be amazed that this South American continent should have been allowed for so long a period to remain undeveloped while at the northern end of that continent the United States has developed to an extent unparalleled in history. It has been customary to term Africa "The dark Continent," but the fact remains that there is to-day no part of the earth's surface which is less known than are vast areas of the interior of South America. There can be little doubt that the 20th century is destined to see an enormous economic development of Latin America comparable to that of the United States in the 19th century. This development will be hastened in the early decades of the present century by the opening of the Panama Canal and in the late decades by the construction of a great Pan-American railway from Canada to Patogonia, which, passing longitudinally along the Central Andean valleys and plateaus will link together the various States which it traverses, and by making connections with transversal railways leading to either ocean will afford ready access to its virgin and unexplored interior.

The countries of Latin America whose trade and economic development will be affected by the opening of the canal may be grouped in four classes. The first class includes those countries whose seaboard is confined to the Atlantic Ocean or Caribbean Sea, viz.: Argentine, Uruguay, Brazil, the three Guianas, Venezuela and

British Honduras. The trade of these countries will only be affected indirectly because of any share they may acquire in the general impetus given by the canal to trans-Atlantic commerce. It is even possible that the trade of some of them may suffer because of the dislocation of existing routes.

The second group includes countries which have no seaboard on either ocean. Of these there are only two: Bolivia and Paraguay. It is unlikely that Paraguay will be affected in any way by the opening of the canal route, since its products will reach the Atlantic by way of the River Parana, or will pass over recent Brazilian and Argentine railways to ports on the Atlantic. On the other hand the economic development of Bolivia will be affected considerably; Bolivia, that Switzerland of South America, which is now progressing rapidly because of the new railways that have been and are still being constructed with British capital. La Paz, the pivot of the Bolivian railway system is in communication with Antofagasta, Arica and Mollendo on the Pacific coast, and these lines will enable some proportion of the products of Bolivia to be captured for the Panama Canal route. But a large proportion of these Bolivian products will be diverted from the Pacific seaboard to the Atlantic through Brazilian territory by way of the Madeira-Mamore railway, and also through Argentine territory by way of the Uyuni-Tupiza line which supplies a long-needed connection with the Argentine railway system at La Quiaca.

The third group includes countries whose ports are confined entirely to the Pacific coast: these are El Salvador, Ecuador, Peru, and Chile. The Republic of El Salvador whose imports come from Great Britain, the United States, Germany, and France, and whose exports go to the United States and France, will benefit by the Panama Canal, as it has already benefited by the opening of the Tehuantepec Railway, which runs along the Mexican depression once proposed as the site of an inter-oceanic canal. Shortly after the opening in 1907 of the Tehuantepec Railway, arrangements were made by the Salvador Railway Company to establish a weekly steamship company of its own between Acajutla, the port terminal of the Salvador Railway, and Salina Cruz. As Acajutla is only thirty-six hours' steam from Salina Cruz, the weekly service of steamers, proceeding direct from Acajutla to Salina Cruz without any intermediate calls, enables Salvadoreans to reach Mexico City in less than four days and New York in less than a week. Ten years ago Salvadoreans could hardly reach New York in less than a month whether they travelled *via* San Francisco or *via* Panama. With the opening of the Panama Canal those exports of Salvador which go to the United States will probably continue to reach that country *via* the Tehuantepec Railway, while those which go to France and other parts of Europe will, partly or altogether, probably reach their destination *via* the Panama Canal. The advantage to the other three republics of Ecuador, Peru, and Chile will be chiefly due to the shortening of route *via* Panama as compared with its distance by way of Magellan Straits. The canal will give a great impetus to the Pacific coasting trade of South America, which was once almost entirely in the hands of two British companies (Royal Mail Steam Packet, and the Pacific Steam Navigation) Companies, but which is now keenly competed for by German, French, Italian, and Dutch shipping companies. And this competition is having an excellent effect in stimulating the economic development of the three republics. Guayaquil has now a reputation nearly as unsavoury as that which Santos, the coffee port of Sao Paulo, once had, but in anticipation of the opening of the canal even the backward inhabitants of Ecuador are now waking up. It is probable that very soon their pest spot, Guayaquil, will be purified and rendered as safe as has been successfully accomplished in the cases of Havana, Santos, Rio de Janeiro, Vera Cruz, and Colon, where similar swamp conditions were once as deadly.

A similar change is affecting these

other states whose outlets are situated exclusively on the Pacific Coast and, more especially the Republic of Chile, whose Government has recently undertaken a most ambitious scheme, the Longitudinal Railway of Chile, which extends from Cabildo, near Valparaiso, on the south, to Arica on the north, whence a railway runs to La Paz. Thus the southern portion of Chile will be brought into direct touch with Bolivia. The natural difficulties to be overcome by this Longitudinal Railway are often very serious, since spurs from the Andes run across to the sea and cut the country up transversely into a series of enclosed valleys and mountain ranges. The railway will give an outlet to the agricultural products of these rich valleys, and make Chile less dependent on the nitrate industry, the fluctuations of which have such an influence on its financial position. It will also connect up the different railways which run from the coast to the interior and which are at present isolated from each other, and will render possible the journey from Bolivia to Valparaiso and Santiago and other places further south. It has also great importance from an international standpoint. When in future, passengers from the United States have reached La Paz, the capital of Bolivia, it will be possible for them to proceed to Patagonia by the well-developed Argentine system, or to Southern Chile by this Longitudinal Railway. By the end of the present decade of the 20th century the only gap in this Pan-American railway will be between Lima in Peru and Darien in Panama, and even that will be interrupted by portions in Northern Peru, Ecuador and Colombia. All these States are capable of enormous development, and herein lies a fundamental difference, as regards commercial significance, between the Panama and the Suez Canals. The Suez Canal was constructed at a comparatively low cost and connects Europe, Asia, Africa, and Australia, continents which contain much the largest share of the population of the earth. On the other hand, the Panama Canal cost a vast amount of money, and the Western Pacific coast of the American continent which it connects with Europe and the Eastern States, is not at present comparable in commercial importance with India and the East Indies which are similarly served by the Suez Canal. Convenient access was afforded by the Suez Canal to countries which had already attained to a high degree of economic development, as well as to an archipelago and an island continent of great possibilities. The vast expansion of trade which followed its opening resulted in its great financial success; its original shares multiplying a dozen times in value, and the dividend paid to its shareholders reaching as high as 26 per cent., a percentage greater than even Count de Lesseps considered desirable, holding that excessive profits should be applied to the reduction of the dues payable by shipowners. The construction of the Panama Canal, on the other hand, precedes the expected development of the regions to which it opens a convenient door, for the partially barren west coast of South America lies close to the great Andean zone of lofty valleys, plateaus, and parallel cordilleras, all teeming with the precious metals in almost fabulous abundance—the real El Dorado of the future. But this vast amount of mineral wealth must be exploited to a much greater degree than at present is possible because of the lack of cheap transit on high roads and railways, before the Panama Canal can be expected to reap any advantage. The difference between the two canals is comparable with that between a railway constructed in the early fifties to serve a populous region, and one of the trans-Continental pioneer lines of Canada or the United States which precedes the economic development of the regions through which it passes.

The fourth group includes countries with ports on both coasts, viz.: Canada, the United States, Mexico, Columbia, and all the Central American States except Salvador. These have all railway communication from ocean to ocean with the exception of Honduras, Nicaragua and Colombia. In Costa Rica the United States Fruit Com-

pany's line extends from Port Limon on the Caribbean Sea up the deeply eroded valley of the Reventazon River, past the capital, San Jose, to Alajuela on the Pacific Slope. The Costa Rica Government constructed a line from San Jose to the Pacific coast, and these two railways constitute an inter-oceanic route which can, however, never seriously compete for through traffic with the Panama Canal. The same applies to the interoceanic route through the Republic of Guatemala, formed also by two railways, one from Port Barrios to the capital and the second from the latter city to San Jose de Guatemala. There remain to consider, therefore, only the Tehuantepec Railway and the trans-Continental railways of the United States and Canada.

Of these the most formidable competitor is the Tehuantepec Railway, which at present because of its extreme shortness—less than 200 miles—and its good management, competes seriously with the trans-Continental lines to the north which are over a dozen times its length. Both the Tehuantepec Railway and the Panama Canal will provide convenient outlets for the enormous tracts of land that in North-Western Canada are now being fast settled by English and Scotch colonists. The grain and fruit of these fertile regions as well as the timber and fish from their virgin forests and teeming waters will reach Europe in large quantities by the short land route and the still shorter waterway which are both situate far south in the tropics.

# Current Topics

### Geared Turbine Ship on Isle of Man Service.

We recently crossed from Liverpool to Douglas, I.O.M., on the new Isle of Man Steam Packet Co.'s geared turbine steamer, the *King Orry*. She has been in service since the middle of July, and great interest is being shown in engineering circles in the performance of the vessel, on account of the propulsion system with which she is equipped. The principal dimensions are :—312 feet by 43 feet by 24 ft. 9 in., and the service speed is about 21 knots. The *King Orry* carries a crew of about 75 persons, and has a passenger capacity of about 1,600. The vessel is provided with nine water-tight bulkheads, which extend to the upper deck, the water-tight doors (on the Stone Lloyd system) being capable of being closed from the bridge. Of chief interest, however, is the propelling system. There are two high and two low

pressure Parsons turbines of the combined impulse and reaction type, one high and one low pressure turbine being coupled to each of the two propeller shafts through double helical gearing. The propeller shafts make 300 R.P.M., the high-pressure turbines 2,400 R.P.M., and the low-pressure machines 1,600 R.P.M. The total power is 8,000 H.P. There are two sets of double helical gear wheels, each consisting of two pinions and one spur wheel, the pinions being mounted on the high and low-pressure turbine shafts, and both meshing with the single spur wheel on the propeller shaft. Lubrication of gears and bearings is by a special sprayed and forced system. The noise from the gear appeared to be quite unobjectionable although perceptible. It is understood that experiments are to be made with laggings for the gear cases to reduce still further the small humming note that is at present noticeable. The humming only seemed to obtrude itself upon one's notice during periods of acceleration, as when leaving the Liverpool stage and when manœuvring at Douglas Pier. Moreover there seemed to be considerably less vibration apparent than is the case on many turbine-driven steamers—than, for instance, on the *Viking*, owned by the same company. Perhaps this is due in a measure to some damping-out tendency in the gearing. The *King Orry* is certainly a worthy addition to what is already a most comfortable line of steamers, and the slight permanent list with which she seems to be afflicted at present was not appreciably apparent. The builders of the *King Orry* were Messrs. Cammell, Laird & Co., Ltd., of Birkenhead.

### The Rise in Wages.

ACCORDING to a Board of Trade report, just issued, the year 1912 witnessed a very substantial rise in wages, a rise spread over a wide field. The weekly amount of the advance was £139,000, for 1,818,000 workers, which represents a yearly increase of over seven millions. These figures, however, only deal with certain trades and are exclusive of changes affecting railwaymen, seamen, and agricultural labourers, many of whom also received advances during the same period. Moreover the unreported changes in unorganised trades are also not taken into account, and as these trades have been affected by the same causes, it is very probable that the average wage here has also undergone an advance. It is, therefore, seen that the rise has been a very large one, as indeed was to be expected during the period of trade prosperity and from the need of meeting the concurrent rise in the cost of living. This aggregate advance, which has been accompanied by a decrease in working hours, is in excess of that for any previous year except that for 1900 and 1907—years of exceptional prosperity. Calculating from 1893 and setting off the periods of depressed trade and decreased wages against periods of prosperity and increased wages, there is still a net weekly increase of £467,000. The high water mark for the present, however, has not been reached for during the first eight months in this year wages have risen at an accelerated rate, the total increase for this period being greater than that for the whole of 1912. The analysed statistics are, of course, not yet available, but probably the year 1913 will create a record.

In the engineering and shipbuilding trades 275,297 workers received increases amounting to £23,888 per week, among which one of the most important increases was 5% on piece rates and 1s. per week on time rates to 42,000 people in federated shipyards on the North-East Coast, the Clyde, and East Coast of Scotland. Reductions of hours in these groups of trades amounted to 34,690 per week, affecting 16,908 persons.

### A New Type of War Vessel.

WITH the launch of H.M.S. *Aurora*, another practically new type of vessel makes its appearance in the Navy. Laid down on October 24th, 1912, at Devonport Dockyard, she was launched on October 1st, 1913.

By the entire substitution of oil for coal fuel a considerable saving in

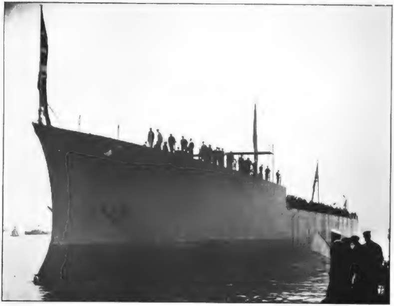


*Photo by* ] H.M.S. AURORA. [ *Abrahams.*

This photograph was taken immediately after her launch. Built at Devonport Dockyard, she is the first of a new type, oil fuel "Destroyer-Destroyers," of which sixteen are to be built.

weight was effected, and although 410 ft. long the displacement is only about 3,500 tons. The turbines develop 30,000 horse power, and a speed of thirty knots. This vessel might aptly be termed a super-destroyer for her chief role is to be the destruction of destroyers, for which her great speed combined with other qualities is eminently suitable. It is in fact another instance of the curious evolution which is being witnessed in modern naval design. As the torpedo boat gradually became merged in the destroyer, or rather *vice versa*—for the destroyer is now really a torpedo boat —and as the large cruiser is becoming identified with the battleship under the style of battle-cruiser, so this new arrival threatens to merge the light cruiser and ocean-going destroyer. For it must be remembered that such a vessel as this will, in addition to destroying torpedo craft, be available for commerce protection.

Considerable secrecy is being maintained with regard to the armament, and other details. It is surmised that she will carry two 6 in. and ten 4 in. guns, and have a vertical armour protection of a thickness on the waterline, varying from five inches to two and a half inches at stem and stern.

The *Aurora* is the first of eight ships of her class provided for under the 1912 estimates, while another eight are included in the current programme.

These vessels were described by Mr. Churchill in the House of Commons as the smallest, cheapest, and fastest vessels, protected by vertical armour, ever projected for the British Navy.

**A New French Dreadnought**

TURNING from our own to the French Navy, we have to record the launch of the super Dreadnought *Lorraine*. She is, of course, the third of the *Bretagne* type, of which two were launched in the early part of this year.

According to the *Telegraph*, she is 541 ft. in length, 51 ft. in beam, with a draught of 29 ft. 6 in. and a displacement of 23,550 tons. With a horse power of 29,000. It is estimated that she will attain a speed of 21 knots. The main armament will consist of ten 13.5 in. guns with a secondary battery of twenty-two 5.5 in., and four submerged tubes. The large guns are in five double turrets, giving a fire of ten guns on either broadside.

The time taken since this vessel was laid down as compared to the time taken with the two sister ships, shows a distinct reduction, being 10 months only, whereas 11½ months elapsed between the laying down and the launch of the other two vessels. In fact, it is satisfactory to note that a distinct improvement in the regularity of naval construction is characterising the present administration.

The next group of capital ships due, the *Normandy* class, will represent another advance. They will carry twelve instead of ten 13.5 inch guns in three quadruple gun turrets—an entirely new departure—with twenty-four 5.5 in. and six submerged tubes. Their engines will be more powerful, developing 32,600 h.p., giving a speed of 21.5 knots.

**The "Model Engineer" Exhibition.**

THE biennial exhibition, held at the Horticultural Hall, Westminster, from October 10th–18th, was the fourth of the series, the first having been held in 1907, and its standard of excellence was more than maintained. A very comprehensive range of models was on view, and the newer branches, such as wireless telegraphy and æronautics, were well represented. A special room was devoted to each of these, a complete working installation of wireless, with ærial on the roof of the hall, having been erected.

Apart altogether from the popular interest attaching to such exhibitions, there is a very valuable practical side, for it is beyond dispute that model making by boys forms a very valuable basis of technical training. But what, perhaps, struck us most was the variety of callings in which these model makers were engaged. There was a beautifully finished model of an express locomotive by a butcher, and a hydroplane by a grocer, to quote but two cases. Indeed, the majority of the models had been made by those whose only interest in engineering was as a hobby. As very many of these builders had never had any training in mechanics, or instruction in the use of tools, one cannot help feeling that their inherent mechanical instinct must be very strong. Nor can one help thinking what a vast amount of mechanical genius is practically running to seed, and how many men who ought to be engineers are engaged in professions for which they are totally unsuited, or where, at least, their mechanical gifts are altogether wasted.

This is the sort of thing that brings home to us the necessity of extending technical education, so that those who have talent may develop it in time to put it to practical use.

**International Electro-Technical Commission.**

THE fourth annual report of this body once again bears witness to the practical nature of the work done. The necessity for international uniformity of terminology and technical standards is too apparent to need labouring here.

It is interesting, however, to note that the Commission is not confining itself too strictly to merely electrical matters. At the Turin meeting attention was drawn to the fact that much inconvenience is often caused to electrical engineers by the lack of uniformity in the definitions of apparatus used in hydro-electric and steam-electric installations, and a Committee was appointed to report on the matter.

Since the publication of this report the Plenary meeting has been held in Berlin, and a number of definitions dealing with hydro-electric work were finally adopted. In addition an International Standard for copper was agreed to, so that in future all tables for copper will be calculated on an identical basis, which will undoubtedly prove a great convenience.

It is satisfactory to know that the work of the Commission is being recognised by many Governments, and is receiving grants in aid from several.

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### The First Oil Fuel Battleship.

THE launch of H.M.S. *Queen Elizabeth* marks a new era in warship building. She is to be driven entirely by oil fuel—no coal whatever being used—she carries eight of the new 16-in. guns, besides sixteen 6-in., and she is designed to secure protection from attack by aircraft. In all these respects she is unique. She is, moreover, the largest ship yet constructed for the Navy, having a displacement of 27,500 tons, length of 650 ft., beam, 94 ft., and mean draught, 27½ ft. Her engines (Parsons' turbines) will develop 58,0 0 shaft horsepower, which will give her a speed of about 30 knots, and her cost when complete will be probably over £2,300,0 0. She was built at Portsmouth Dockyard, and there are four sister ships under construction at the present time.

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### The "Volturno" Disaster.

THE past month has indeed been a black one in its record of disaster, and once again the world has been shocked by an appalling tragedy at sea. Many lives have been lost, and rightly or wrongly the public are beginning an agitation for the revision of fire extinguishing arrangements. However perfect such arrangements may be, at sea as well as on land, there always will remain the risk of fire. At the present juncture the facts are not sufficiently well known to offer an opinion as to whether the arrangements for fire fighting on the *Volturno* were satisfactory or otherwise, nor can any good purpose be served by rushing into print with articles calculated to lessen the confidence of the public. Such disasters, however, call for calm and intelligent investigation, in order that they may serve as a means of guidance for preventing—as far as possible—their repetition. In an early issue, therefore, and when full information is at hand, we shall publish an article dealing with the whole question of fire prevention in ships, with special bearing upon the recent sad occurrence.

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### The Liverpool Accident.

FOLLOWING hard on the heels of the *Volturno* tragedy, came the pit disaster in Wales and the railway smash near Liverpool.

In regard to the latter, information seems to point to the fact that it is another of those accidents that may be classified as preventable. In our October number we published an article on cab signals and train stops, and it was shown that several of the recent railway disasters would have been impossible had such a system been in vogue. The Liverpool smash seems to come within the category and we have in course of preparation another article dealing further with this important question.

# Book News

## The South American Year Book.

The Louis Cassier Co., Ltd., London. 1913. 31s. 6d. nett.

Considering the amount of English capital invested in South America, as well as the growing commercial and political importance of the South American States, it is a matter of considerable surprise that no such volume dealing with the whole of South America has previously been published. Sectional year books dealing with one or other of the countries have appeared but probably the difficulty and expense of collecting and collating information covering so wide a field has deterred the undertaking of so large a task. The present volume, however, certainly fills the gap in most satisfactory manner with a mass of comprehensive information relating to the whole of South America. It is well illustrated with specially prepared maps showing the latest railway construction and with numerous photographs of places of interest.

The year book is divided into two parts, the first dealing exhaustively with the railways of each state, giving the various lines, legislation relating to them, gauges, and other technical details, latest returns available, &c. Part II. gives a short historical sketch of each country, lists of diplomatic and consular representatives, and of foreign firms trading there, postal, telegraphic, shipping, banking and financial information, together with many other matters of interest to business firms, financiers, and all others connected in any way with South America. Now that such a book is available, none such can longer afford to be without it.

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## Engineering as a Profession.

By A. P. M. Fleming, M.I.E.E., and R. W. Bailey, B.Sc. John Long, Ltd., London, 1913. 2s. 6d. net.

Owing to the lack of cohesion that exists in the profession, there is no organised body—as in Law and Medicine—to draw up regulations for the education and training of the young engineer. Much has been written from a theoretical point of view as to the manner in which the various portions of such training should be correlated, etc., but the volume before us is a book written on eminently practical lines intended for the guidance of parents and guardians, and it certainly appears to us that the subject has been treated in a most comprehensive manner.

The various branches of the profession are described and the estimated cost of training is given. The chapter devoted to the means of obtaining a thorough training at minimum expense should prove of particular interest to those of limited means. Lists of firms taking apprentices are given, together with brief particulars as to length and course of instruction. Then having dealt with the education of the engineer the authors review the appointments—Government and otherwise—open to them and the means of obtaining such. This is certainly a book that should be read by every parent who is considering engineering as a prospective profession for his boy.

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## A Text Book of Rand Metallurgy.

Vol. 1. Second Edition. London: Chas. Griffin and Co., 1913. 21s. net.

The two volumes of this publication are complete in themselves. This, the first volume of a second edition, with 128 illustrations, is written by nine authors and deals with the Rand and its mines on general lines, with subsequent chapters on Sorting and Breaking, Stamp Milling, Tube Milling, Sand Treatment, Precipitation, Clean up and Smelting, Assaying, and Testing Chemistry. There is a final chapter with tables and report forms. Each chapter being written by a

specialist in one particular detail is thus likely to be more definite and certain than it could be in any single author treatise. But the practice on the Rand is perhaps somewhat stereotyped in some respects, such as tube milling. Is it so certain that the tube mill is one half so efficient as its rapid adoption would lead one to imagine? Is it not a sort of cult? Does the Conical Mill receive the attention its principles entitle it to do? and has any trial ever been made with positive grinders on the lines of Hoyle's Mill, so very successfully used in cement grinding? The wear of the tube mill seems enormous.

The Rand, as a great mining fact, stands quite alone. Never before has there been such a concentration of effort on a mass of low-grade propositions which have been energetically exploited by powerful appliances. Rand mining has become an industry on the lines of cotton spinning, and this book tells the story.

### The Cyanide Process of Gold Extraction.

By James Park. 5th edition. London Chas. Griffin & Co., Ltd., 1913. 8/6 net.

This book is a complete treatise on the subject of cyaniding for gold recovery, the chemical side of the question being the author's strong point. Cyanide of potassium is perhaps the most deadly poison ever to be employed in industry on a large scale, yet few accidents happen. Let us say that the chapter on antidotes appears wrongly placed at the end of the book. It would be better in the front and the book might well start with a short direct caution.

Cyanide is itself exposed to many dangers. In chemical theory it will dissolve forty times as much gold as in practice proves to be the case. The difference appears to be due chiefly to metallic constituents in the ore. The cyaniding process depends for its efficiency upon bringing the solution to the gold. This necessitates fine reduction of the ore for a bit of gold cannot be touched if it is in the middle of a grain of silica. Hence the rise of fine grinding of the ore, a process that has brought to the front the tube mill. All mining men appear to pin their faith to the common tube mill. But this contrivance is at best a crude machine, and the cone pebble mill appears to us better calculated to do the work efficiently. But we wonder that the positive grinder of Hoyle has not been modified to suit the mining industry. Cyaniding is an art which requires both chemistry and engineering to make a success of it. The mining man can find in this book all that is to be known on cyaniding.

### Carburation in Theory and Practice.

By Robert W. A. Brewer. Crosby, Lockwood & Son. London, 1913. 5s. nett.

This volume is intended as a manual of reference for automobile engineers and owners, and appears to us to cover the ground in excellent fashion. As the author states in the preface, the subject of carburation is one which is vital to the automobile movement, and at the present time, in view of the rise into prominence of petrol substitutes, is of special importance. Although the subject has received a large amount of attention from engineers, apparently no book has been written dealing exclusively and comprehensively with the question. This volume is well illustrated, and as the author discusses the matter from a practical as well as a theoretical point of view in order that actual economies in working may be effected it is one that should be in the hands of all owners who take an intelligent interest in their cars.

### Locomotive Boilers and Engines.

By Llewellyn V. Ludy, M.E., American School of Correspondence, Chicago, 1913. Sold by Crosby Lockwood & Son, London. 4s. 6d. nett.

This little book is divided into two parts, the first giving an historical survey of locomotive developments, and the second dealing more particularly with the various parts and auxiliaries, including a section on signalling (American system). Although intended as an elementary text book, a certain amount of technical knowledge seems to be pre-supposed. The

handbook is well illustrated and interesting, and for those students possessing such knowledge appears useful.

**Further Problems in the Theory and Design of Structures.**

By Ewart S. Andrews, B.Sc. Chapman & Hall, London, 1913. 7s. 6d. nett.

Intended to supplement Mr. Andrews' previous work on the same subject, the volume before us is an advanced text book dealing with several problems of importance to engineers omitted from the earlier one. At the risk of laying himself open to criticism on account of undue length, the author has given nearly every step involved in the mathematical processes, for he has found that many students find it impossible to bridge for themselves the gaps frequently left in mathematical reasoning in most text books. The method of influence lines, the application of the principle of work to deflections of framed structures, redundant frames, and rigid arches; portals and wind bracings and secondary stresses are some of the subjects that are comprehensively dealt with in the present work.

**Steam Engine Design.**

By H. E. King, Assoc. M.Inst. C.E., 1913. The Technical Publishing Co., London. 6s. net.

To some extent a reprint of a series of articles which appeared in the *Practical Engineer*. The author chooses a subject difficult to handle. He gives a chapter on types of engines and deals with detail in separate chapters and at considerable length.

It may be desirable that engine designers shall design on the lines indicated. We wonder how many do so? Engines have grown up side by side with physical science and so far as we know they have progressed in size, step by step, and their details have been made successively larger by the guesswork of experience, this part made larger because it worked hot, that part because of too rapid wear; another because it sheared off. The early history of single acting steam engines has one long record of failure, chiefly because its designers were too mathematical, and designed by supposed stresses, neglecting the teachings of old experience, of new parts such as those demonstrated by Wöhler and others. This book is full of useful illustrations, and of detail designs all of which will be useful. A little more reference to first principles would, we feel, be helpful to young engineers. The velocity of steam in a pipe is given for example as so many thousand feet per minute. This may be what practice has fixed upon as useful compromise. But it would have been as well to have started out from a statement of molecular velocity, and the Kinetic theory of gases, for this theory helps one to understand such matters as pipe sizes and condenser happenings.

**Handbookof Structural Steelwork.**

Redpath, Brown and Co., Limited.

In this excellent "Handbook," of nearly 600 pages, the merits of Messrs. Redpath, Brown & Co. and the facilities they offer for business, are modestly confined to eight pages of introduction and four pages of photographs of their establishments. For the rest, the object of the "Handbook" is stated on page 5 as being to present "in as convenient a form as possible all the data required for the design of structural steelwork." We note that the authors give no guidance for designing the stanchion joints illustrated on pages 427 and elsewhere, but, generally speaking, the "Handbook" avoids the common mistake of shirking problems for which it is difficult to lay down unassailable rules, but which have to be solved in practice. Thus, on page 108, they present a formula for calculating the strength of joists embedded in concrete, and furnish several tables founded upon it. Unfortunately, the formula, though imposing in appearance, is entirely empirical, and, in point of fact, the concrete would in many cases be stressed far in excess of the stated safe allowance of 500 lb. per square inch in compression. Thus, in the case of a 5 in. joist embedded in a slab of concrete 12 in. wide, with the neutral axis about 2 in. from the top, the safe load given by their formula would stress the concrete to about 875 lb. per square inch, namely, 75% in excess

of the stated safe allowance. Nothing is said as to the composition of the concrete nor as to how we are to arrive at the *width*, which we are to assume "as acting with steel joists." The fundamental error lies in the assumption that a joist embedded in concrete is thereby "stiffened." All that can be said is that generally, though not in all cases, the joist and concrete together form a composite beam, whose carrying power is greater than that of the joist alone. The safe stresses adopted for stanchions are higher than usual. Thus the safeload given on page 142 for a length of 28 feet of the first section is given as 508 tons, while the safeload for the same section, according to the L.C.C. formula, is given elsewhere as 389 tons. Moreover, in calculating the safeloads on stanchions, no allowance has been made for rivet holes. But the architect or engineer who is sensible enough to realise the inevitable limitations of a book of this kind will find it exceedingly useful, as it is certainly one of the best that has hitherto been published.

**Thirty Years of New York—1882-1912.**

The New York Edison Co., New York, 1913.

In this interesting volume the progress of New York is described. A large number of developments were, of course, directly due to the use of electricity, and it is in this connection that the Edison Company—the pioneers in the movement—have taken upon themselves the task of tracing in this book the various stages in its growth and application. Excellent illustrations of past and present day New York show striking contrasts and afford evidence of the enormous changes that the city has undergone. Interesting details as to the development of the Edison Company are included, and the whole, excellently printed and produced, forms a fascinating record of scientific, commercial, and civic progress.

**All About Engineering.**

Cassell & Co., London, 1913. 6s. net.

This book is written for boys, and as most boys are interested in engineering, it will undoubtedly prove a welcome addition to the series of books of a similar character issued by Cassell & Co., for juveniles. The book is well printed in a nice readable type, and contains many illustrations which will appeal to the young mind.

**Heat Engines (being a New Edition of Steam).**

By William Ripper, D.Eng. Longmans, Green & Co., London, 1913. 3s. 6d.

This is the second edition under the new title and further considerable additions have been made, including new matter on steam turbines, condensers, governors, indicator diagrams, steam separators, &c., accompanied by numerous fresh diagrams.

**Switchgear and the Control of Electric Light and Power Circuits**

By A. G. Collis, A.M.I.E.E. Constable & Co., Ltd., London, 1913. 1s. nett.

**Working of Steam Boilers.**

By Edward G. Hillier, B.Sc., M.I.C.E., &c., Chief Engineer to the National Boiler and General Insurance Co., Ltd. Fifth edition. Taylor, Garnett, Evans & Co., Ltd., Manchester and London, 1913. 1s, 6d.

**Industrial Poisoning from Fumes, Gases and Poisons of Manufacturing Processes.**

By Dr. J. Rambousek, translated by Thos. M. Legge, M.D. Edwin Arnold, London, 1913. 12s. 6d. net.

## SHIPBUILDING AND MANUFACTURING NEWS

**Launch of a Turkish Battleship**

THE accompanying photograph is of the Imperial battleship, *Reshadieh*, taken just after her launch at Barrow-in-Furness, where she was built by Messrs. Vickers Ltd.

This vessel is interesting since her armament at date of launch was more powerful than that of any other vessel. She is 525 ft. in length, with a beam of 91 ft. and a displacement of 23,000 tons. Her main battery consists of ten 13·5 in. guns, mounted in pairs in five barbettes, all on the centre line. By a special arrangement of locating the barbettes at different levels it is possible to obtain the fire of four guns directly ahead and astern respectively, and of course a broadside fire of all ten. Sixteen 6-in. guns form the secondary battery. The engines are Parsons' turbines, and the boilers are of the Babcock and Wilcox type, manufactured by Messrs. Vickers, which are designed to generate 31,000 shaft horse power, giving a speed of 21 knots.

TURKISH BATTLESHIP, "RESHADIEH."
Built by Messrs. Vickers Ltd., at Barrow-in-Furness.

### Trial Trips of H.M.S. "Sarpedon."

H.M.S. *Sarpedon*, an ocean-going torpedo boat destroyer, built by Messrs. Swan, Hunter & Wigham Richardson, Ltd., at their Wallsend Shipyard, has just completed a most successful series of trials at sea. The Admiralty placed the order for H.M.S. *Sarpedon* and *Ulysses* with these builders under the naval programme of 1912-13, and it is interesting to note that she is the first of her class to run her trials at sea.

The sister ship, H.M.S. *Ulysses*, is now being fitted out at Wallsend, and will be ready for her trials in a few weeks. Both these vessels are similar to H.M.S. *Shark*, *Sparrowhawk* and *Spitfire*, which Messrs. Swan, Hunter & Wigham Richardson delivered to the Admiralty a few months ago.

The turbines and boilers of H.M.S. *Sarpedon* were built by the Wallsend Slipway & Engineering Co., Ltd. The former are impulse reaction turbines of Parsons' design, driving two propellers. The ahead and astern turbines are both enclosed in the same casing. The boilers, which are of the Yarrow water tube type, have oil burning furnaces. An ample supply of steam was steadily maintained during all the trials. These included an eight hour's run at full speed, a twenty-four hour's trial at cruising speed, a trial running astern, steering and turning trials, gun trials under service conditions and testing all the deck machinery and the torpedo launching tubes. The engines of H.M.S. *Sarpedon* are now being opened out for inspection, after which the ship will be made ready for acceptance by the Admiralty.

### Armstrong Torpedoes.

In our issue for September we published an article on the Evolution of the Submarine containing some figures from "Le Yacht" regarding the Armstrong heater torpedo. We understand that these figures are not correct as regards recent results obtained with this torpedo. The following are the speeds obtained with the latest type manufactured by Sir W. G. Armstrong, Whitworth and Co., Ltd. :—

| | | |
|---|---|---|
| Up to 1,000 metres | .. | 47 knots. |
| ,, 2,000 ,, | .. | 45 ,, |
| ,, 3,000 ,, | .. | 40 ,, |
| ,, 4,000 ,, | .. | 38 ,, |
| ,, 5,000 ,, | .. | 34 ,, |
| ,, 6,000 ,, | .. | 32 ,, |
| ,, 7,000 ,, | .. | 30 ,, |
| ,, 8,000 ,, | .. | 28 ,, |

### Trial Trip of the s.s. "Kandahar."

The *Kandahar* is a fine specimen of a modern cargo ship, and has just successfully run her trials at sea. She is the fifteenth vessel built by Messrs. Swan, Hunter and Wigham Richardson, Ltd., for the lines controlled by Sir John Ellerman, Bart. The triple expansion engines and also boilers of the vessel were supplied by the Wallsend Slipway and Engineering Co., and they worked without a hitch during the trial, to the satisfaction of all concerned. A speed of nearly fourteen knots an hour was easily maintained on the measured mile. An interesting feature in the ship is the cruiser-shaped stern, which is a most uncommon feature in a cargo ship and gives increased carrying capacity. Messrs. Swan, Hunter and Wigham Richardson, Ltd., were pioneers in the introduction of this shape of stern for merchant vessels. The leading dimensions of the s.s. *Kandahar* are 449 feet overall and 55½ feet broad, with a deadweight carrying capacity of 10,400 tons.

The s.s. *Edward L. Doheny* is another vessel built and engined by the same firm, and has recently completed a very satisfactory series of trials. The steamer, which is built of steel, is intended for the carriage of oil in bulk. She has been constructed on the Isherwood system of longitudinal framing, and is 430 ft. in length.

In every way the steamer is an up-to-date and complete oil tank vessel, carrying over 9,800 tons total deadweight. The auxiliary deck machinery includes steam windlass, steam and hand steering gear, two steam winches, etc., etc. There are oil cargo pumps of large capacity to ensure very rapid

discharge of cargo. The engines and boilers are placed aft, and consist of a set of triple-expansion engines, supplied with steam from two large boilers working on the Howden system of forced draught, and arranged to burn oil fuel on the Wallsend-Howden system.

The vessel is the second oil tank steamer constructed at the Neptune works for the same owners; the former one, the *Norman Bridge*, a slightly smaller boat, having been running very successfully on her service for some months.

### 46ft. Launch for Spain.

THE deliveries from the yards of Messrs. John I. Thornycroft and Co., Limited, during the past few weeks have been exceptionally heavy in marine motor craft, and among the more important is a well-equipped launch supplied to the order of the officers of the Spanish Naval Commission, for the use of the port officers at Cadiz.

The launch in question is built of teak, being 46 ft. in length by 8 ft. beam, and is fitted with a "Thornycroft" 6 cylinder motor of the "M" type, giving a speed of 9½ knots per hour. Upon the four-hour full speed trial on the Thames, recently, with the officers in attendance, they expressed their satisfaction of the design and finish of the boat, and also of the quiet running of the engine.

### Citroen Gears for Dredgers.

THE dredge, *John Stewart*, recently built at the New South Wales Government dockyard is specially interesting from the fact that it is fitted with Citroen gearing, and so is in some ways a new departure. The Sydney *Daily Telegraph* gives the following particulars, taken from the engineer's official report:—

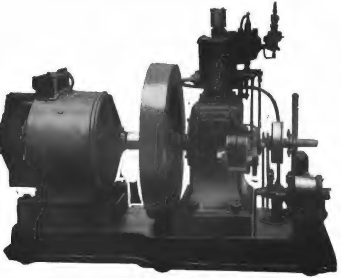
"The dredge is of the following dimensions:—Length over all, 160 ft.; between perpendiculars, 152 ft.; beam moulded, 32 ft.; depth, moulded, 11 ft. 9 ins.; draught, 8 ft.; displacement, about 800 tons. Her engines, 20 in. and 40 in., are of the compound surface condensing type, having a 24 in. stroke. A unique feature of this dredge is the fitting of double helical gearing with machine cut teeth, technically known as "Citroen" gearing, and this is guaranteed to give 98 per cent. efficiency as between driving and driven shafts. This was made a special feature of in the original specification, in which it was pointed out that the best possible results which should be obtained with ordinary gearing would not exceed 65 per cent., and might probably be less. With the "Citroen" gearing, however, a guarantee of 95 per cent. efficiency was given, so that in an engine of 510 H.P. there would be a saving of about 130 H.P. The results of the trials showed that the saving was even greater, and the engine designed capable of developing 510 H.P., was only called upon to develop 200 H.P.

"The dredge is fitted with very powerful winches fore and aft for the manipulation of the cables, thus obtaining her full working capacity during dredging operations. The whole of the machinery, including all auxiliary and steam steering gear, has been manufactured at the dock from special designs, and, with the exception of anchors and chains and some raw material, such as steel plates, the dredge has been constructed from material almost wholly Colonial. On the trials the machinery worked satisfactorily, and during one hour's work, upwards of 1,300 tons was dredged, although the specification only calls for 1,000 tons per hour. The vessel takes Lloyd's A1 class, special survey."

Since this dredger was put in operation another exactly similar vessel, constructed at the same dockyard, has also been fitted throughout with Citroen bevel gears, so they have evidently been found satisfactory.

### "Endee" Pumps.

MESSRS. NORMAN DICKSON, PRINGLE AND CO., of 25, Victoria Street, S.W., and Hogarth Works, Chiswick, the designers of the "Endee" air pumps, inform us that they have lately secured an order from H.M. Post Office for port-



ELECTRIC LIGHTING SET WITH "ENDEE" PUMP FOR USE ON A YACHT.
Manufactured by Messrs. Norman, Dickson, Pringle & Co.

able petrol driven sets, embodying their class H., size 2 "Endee" air compressors. These air pumps are made single stage for low pressures up to 35 lb. per square inch and two stage for pressures ranging from 35 lb. to 120 lb. per square inch, and over, these latter being generally provided with water cooled cylinder covers.

The arrangement of valves and seats (which is patented) is, perhaps, the most striking feature of these pumps, as it permits both suction and delivery valves to be withdrawn simultaneously and also the direction of the flow to be reversed, the operation only taking a minute or so. By these means the compressor can be made into a vacuum pump, or vice versa. The clearance (unavoidable in all pumps) is, with this valve arrangement, extremely small. The connecting rod is made in cast steel, with adjustable large end bushes. The adjustment, when necessary, is made with one screw only, which can be turned with a tommy, the screw being provided with a secure locking device. The lubrication of the main bearings is effected by continuous ring oiling, whilst the two pistons (cast in one) and connecting rod bushes are lubricated from two adjustable sight feed glass cup lubricators, which are screwed into the top of the crank-case.

For a small extra charge the pumps can be fitted with an automatic unloading device, which allows the machines to run light when the desired pressure has been attained in the receiver and re-starts the pumping when the pressure in the receiver alters a pound or so. These pumps are made capable of dealing with any quantity of air up to 250 cu. ft. per minute, and are capable of compressing up to 200 lb. per square inch. The illustration which we give shows a set designed and supplied for use on yachts and motor boats; comprising an electric lighting set with an "Endee" valveless differential water pump for dealing with bilge and scouring the decks. "Endee" com-

pressors can also be added for blowing syrens, etc. The whole compactly mounted on a bedplate, makes an efficient and necessary addition to the well equipped yacht.

Messrs. Norman, Dickson, Pringle and Co. have received many repeat orders, which may be regarded as a guarantee of the satisfaction which the "Endee" manufactures always give.

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### The Scientific Testing of Fabrics, Twine, Cord, &c.

THE proved strength of fabrics, twine and other similar materials must of necessity be of interest to a large number of our readers, and we have pleasure in describing a machine specially manufactured by W. & T. Avery, Ltd., of Birmingham, for testing the materials used in the manufacture of aeroplanes, monoplanes, hydroplanes, &c., &c., where reliability of the most exacting nature is of the greatest importance as can be readily concluded. These machines are also used in testing cloth, &c., and have been installed in Government clothing factories, the largest contractors to His Majesty's Government, as well as Technical Colleges, &c.

The machine has a capacity of 1,200 lb. on the combined lever, and 240 lb. single lever and specimens can be tested up to 28 ins. stretched length. The strain is applied by means of fine shot flowing into a receiver suspended at the end of a weighing steelyard; the flow of the shot is regulated by a special valve which remains constant at any position in which it is fixed. Gearing worked by hand is provided for, taking up the elongation of the specimen and balancing the strain applied by the falling shot. The steelyard is graduated on both sides, the graduations on the one side range from zero to 200 lb. by 1 lb. divisions, and those on the other from zero to 40 lb. by 1-5th lb. divisions. This is used for weighing the amount of shot at the end of the test and the reading gives (not the weight of the shot) the actual load applied to the specimen. The side graduated from zero to 200 lb. is used when the machine is arranged with compound levers. When delicate material is to be tested, the single lever portion is used, being turned round into position, taking the single lever directly over the bottom grip. A spring balance is interposed between the receiver and the steelyard, the dial of which is graduated to the maximum load, *i.e.*, 1,200 lb. and 240 lb. respectively. This enables the operator to read the approximate load on the specimen at any moment during the test, but the full load is taken on the steelyard.

TESTING MACHINE FOR FABRICS, TWINE, &C.
Manufactured by W. and T. Avery, Ltd., Birmingham.

The method of testing is as follows: the specimen being inserted in the grips, the shot is started to flow from the fixed reservoir into a can, which is suspended from the floating steelyard. For low capacities a quick speed

is used for the strain and the weighing apparatus turned round so that the steelyard can be used as a single lever. For high capacities a slow speed is used and the main lever and steelyard are compounded.

When the specimen has broken, the shot is emptied from the receiver into the can suspended from the link hanging from the rear of the steelyard and there balanced by means of the loose proportional weights and the sliding poise, the strain then being read off.

The illustration depicts how such difficulties can be mastered in a simple manner, and the coal conveyed automatically from the loading point to the boiler house, by a wire ropeway. The plant illustrated was built on the system of Bleichert's Aerial Transporters, Ltd., London, E.C. A telpher operating with an automatic grab was erected on the railway siding. The winch-car lowers the open grab into the railway trucks, whereupon the clams close, the grab is again raised, and the car runs over the loading hopper, into which the grab discharges its contents. From here the coal is drawn off into ropeway cars, which carry it to the works at a distance of about 1,380 feet away. It is worthy of notice that the ropeway only requires attendance at the loading point, as both the curves at the approach to the boiler house and the return sheave are negotiated automatically by the cars. The whole conveying operation is therefore attended to by one man. The hourly capacity of the plant amounts to 25 tons, the river being crossed at a height of about 66 feet. A bridge is also provided as a safeguard against any falling pieces of coal.


TELPHER WITH AUTOMATIC GRAB FOR HANDLING COAL.
Built by Bleichert's Aerial Transporters, Ltd.

**Coal Handling by the Telpher System.**

ALTHOUGH works and factories are usually located on a waterway or alongside railways, so that coal can be carried to the boiler bunkers or storage ground direct by means of telphers, bucket conveyors, or by the more modern method of telphers operating with grabs, it will, however, frequently occur that such undertakings are found at a distance from any line of thoroughfare. In such cases it is necessary to adopt measures to get into connection, if possible, with the railway or waterway, though the problem may have become very complicated on account of intervening land and houses, streets and roads.

Mr. J. M. Allan, who recently took up the appointment of managing director to Cammell, Laird and Co., Ltd., at Sheffield, was for many years associated with Messrs. R. and W. Hawthorn, Leslie and Co., Ltd., and at the time of severing his connection with that firm was managing director of St. Peter's Works.

Mr. Allan commenced his engineering training in the works of Messrs. Palmer and Co., at Jarrow, and, on the termination of his apprenticeship, joined the P. & O. Co.'s staff. While serving with this company, he was, for a period of four years, attached to the staff of the superintendent engineer abroad. On returning to England, he joined Messrs. Hawthorn, Leslie and Co., and in 1900 was appointed general manager, and, as already stated, eventually became managing director of their St. Peter's Works.

Of late years these works have been almost exclusively engaged on naval engineering contracts of a very important character, and for their execution Mr. Allan was largely responsible. The clients of the firm included British, Norwegian, Russian, Italian, Chinese, Chilian, Brazilian, Turkish, and other Governments, and the work was of a very diversified character. In this connection it is an interesting fact that at St. Peter's Works, during Mr. Allan's régime, a greater number of British battleships of the Dreadnought type have received their propelling machinery, of the Parsons turbine type, than at the works of any other firm in the United Kingdom. Many cruisers, coast defence battleships, torpedo destroyers, and torpedo boats, etc., have also been fitted out, indeed, nearly 70 vessels for the British Navy alone have passed through Mr. Allan's hands.

J. M. ALLAN, M.I.N.A.

See reverse side.

CASSIER'S ENGINEERING MONTHLY

INCORPORATING CASSIER'S MAGAZINE

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# THE WORLD'S OCEAN-GOING TRADE, WITH SPECIAL REFERENCE TO BRITISH SHIPPING

A REVIEW: 1904-1913

By Brysson Cunningham

IN November, 1904, there appeared in this magazine an article dealing with the oversea trade of the United Kingdom in its relation to that of other nationalities, and a series of graphical comparisons were made to show how large a proportion of the world's trade was in British hands. The lapse of nearly a decade since that date renders it interesting and instructive to review the situation and ascertain how far the supremacy has been maintained and whether any, and if so, what causes are operating to effect a change.

Within the period under review a very marked development and expansion of shipbuilding enterprise has taken place. This is more or less common knowledge, but it is not until a backward glance has been cast over the intervening years and a survey made of the conditions prevailing in 1904, that the significance of the movement is fully appreciated. At that epoch the distinction of being the largest vessel in existence was held by the *Baltic* of the White Star Line. Her gross tonnage was 23,876, and it is startling to realise that this is merely half or less than half of the individual tonnages of five present day leviathans. Yet in 1904 the *Baltic* was *facile princeps*, and stood proudly head and shoulders above her competitors. Her only serious rivals were the *Cedric*, the *Celtic* and the *Minnesota*, each just over 20,000 tons. There are now in existence sixteen vessels exceeding this limit—it is noteworthy that eight of them fly the British flag—and of these sixteen, four average 50,000 tons each, the highest being 56,000 tons.

To appreciate still further the rapidity with which this development has taken place, let us look back another decade. Twenty years ago, the 10,000 ton vessel was regarded as an exceptional monster. At the present time there are on the register just over 200 vessels of calibre ranging from 10,000 tons upwards, and, of these, it is also interesting to note that 129, or 65 per cent., are British, 34 are German, 11 are American (United States), and the same number French.

The diagram (Fig. 1) shows the order of the construction of important vessels (of 15,000 tons and upwards) since the beginning of the present century. It will be noticed that the year 1907 formed a temporary climax in their production. There was a distinct

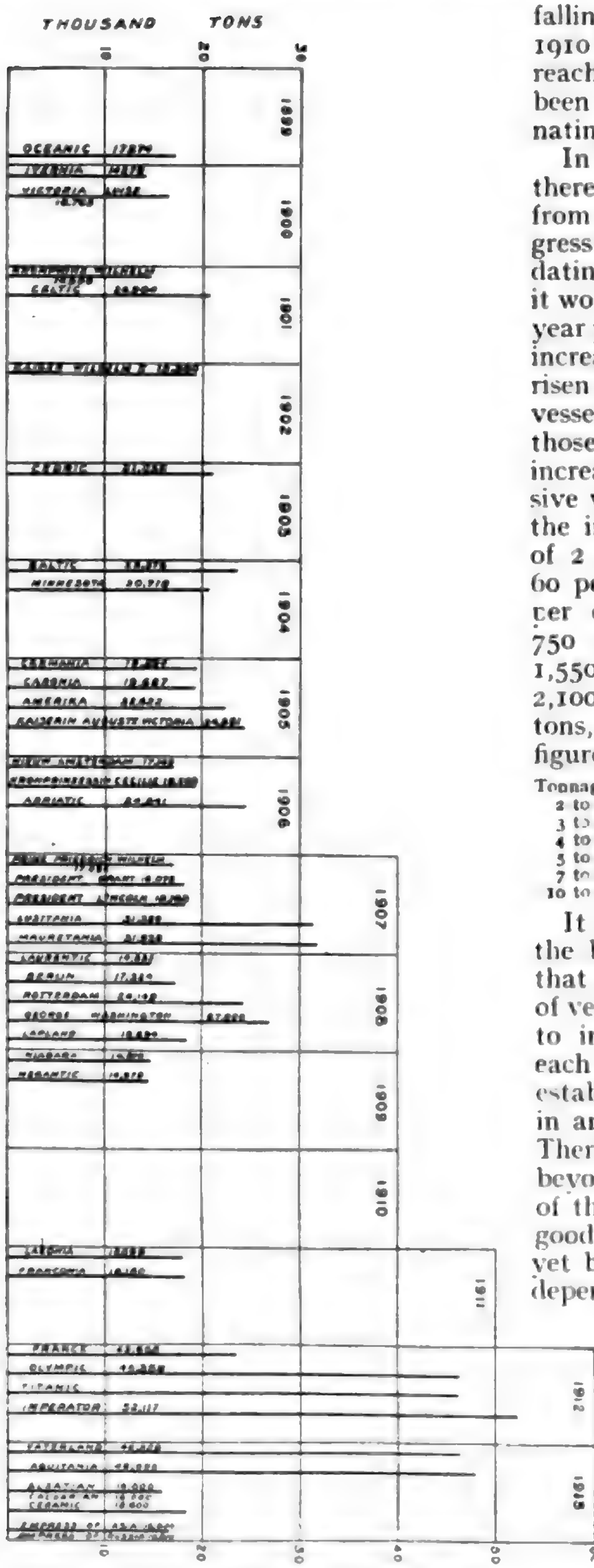



FIG. 1.—DIAGRAM SHOWING VESSELS OVER 14,000 TONS BUILT FROM 1899-1913.

falling off in 1908 and 1909, while in 1910 the nadir of non-production was reached. Of late, however, there has been a decided recrudescence, culminating in the *Imperator* of last year.

In *Engineering* of April 18th last, there was published a table, compiled from Lloyd's Register, giving the progress in tonnage range of large steamers dating from the year 1891, from which it would appear that taking the twenty year period of 1891 to 1911, the relative increase in the number of vessels has risen very much more rapidly among vessels of large tonnage than among those of small tonnage—in fact, the increase has been consistently progressive with the size of the vessel. Thus the increase in the number of vessels of 2 to 3,000 tons has been roughly 60 per cent.; of 3 to 4,000 tons, 380 per cent.; of 4 to 5,000 tons over 750 per cent.; of 5 to 6,000 tons, 1,550 per cent.; of 7 to 10,000 tons, 2,100 per cent.; and of 10 to 15,000 tons, 5,400 per cent. Here are the figures :—

| Tonnage range | 1891 | 1896 | 1901 | 1906 | 1911 |
|---|---|---|---|---|---|
| 2 to 3,000 | 1,464 | 1 961 | 2,095 | 2,288 | 2,308 |
| 3 to 4,000 | 441 | 737 | 1,199 | 1,701 | 2,108 |
| 4 to 5 000 | 152 | 304 | 472 | 885 | 1,298 |
| 5 to 6,000 | 53 | 148 | 376 | 601 | 875 |
| 7 to 10,000 | 13 | 29 | 85 | 174 | 295 |
| 10 to 15 000 | 2 | 6 | 50 | 83 | 110 |

It is obvious that this is the day of the big ship. The shipowner realises that rather than multiply the number of vessels in his fleet, it pays him better to increase the carrying capacity of each vessel, since running costs and establishment expenses do not rise in anything like the same proportion. There must, of course, be some limit beyond which the superior economy of the large single ship ceases to hold good, but apparently this limit has not yet been attained. It must naturally depend on a number of considerations

not merely connected with *personnel* and cost of outfit, but also with questions of convenience and locality.

Our primary object, however, is not to deal with the growth in size of the individual vessel, but rather to consider the aggregate tonnage of merchant shipping, as representing more completely the development of oversea trade. In this respect, too, there has been progress of the most unmistakable kind. The diagram (Fig. 2)

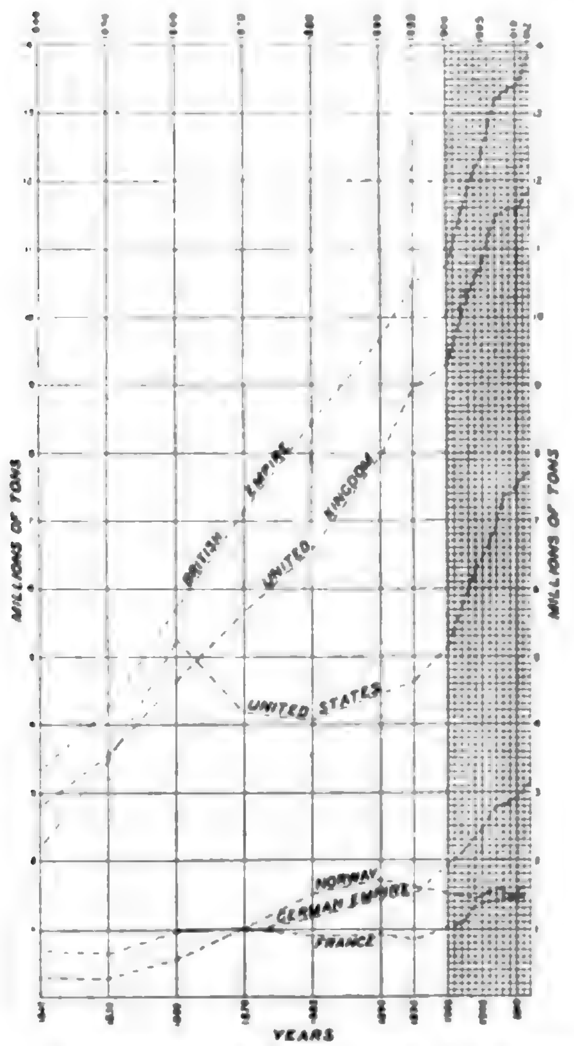



FIG. 2.—CURVES SHOWING THE GROWTH OF TONNAGE OF THE MERCHANT NAVIES OF THE PRINCIPAL MARITIME COUNTRIES FROM 1840-1912.

which represents graphically the growth of the merchant navies of the principal maritime countries of the world, since the year 1840, indicates in the case of the United Kingdom and the British Empire an almost unbroken line of advance at a rate which makes the observer wonder whether it can possibly be maintained, and what the result will be in another fifty years' time. From 3½ million tons in 1840 the British merchant navy has grown to 14 million tons—an increase of more than 300 per cent. in 73 years. Compared with that of other nationalities it is remarkable—one might even say, amazing. The United States merchant navy, which

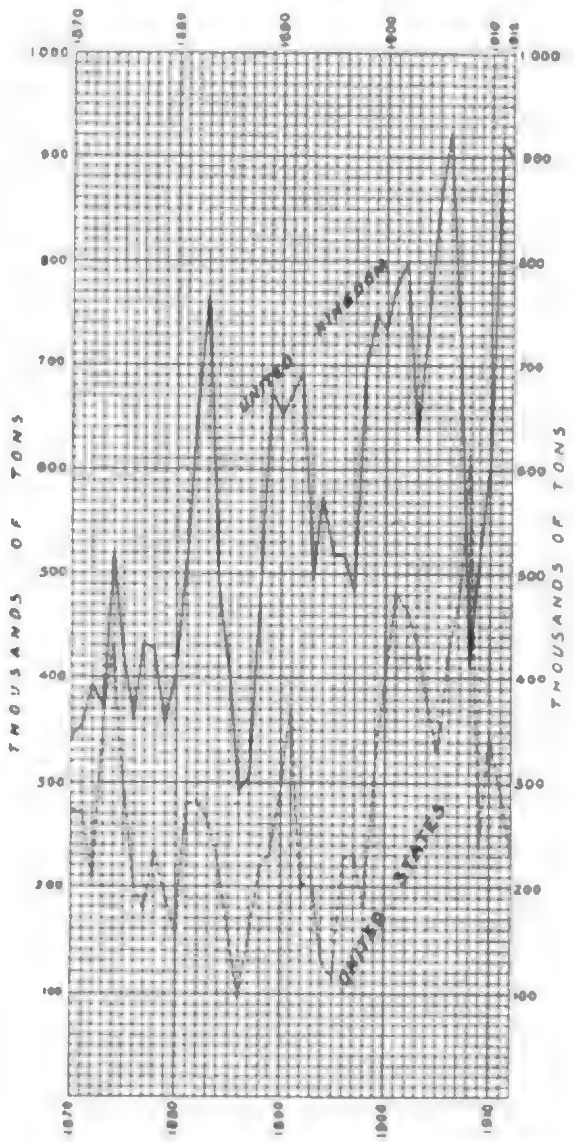



FIG. 3.—DIAGRAM SHOWING THE SHIPPING TONNAGE BUILT IN THE UNITED KINGDOM AND THE UNITED STATES FROM 1870-1912.

comes next in point of size, can only boast a little over 7½ million tons, and this total includes lake and river steamers of 5 tons and upwards. If vessels engaged in foreign trade only be taken, the figure shrinks to less than a million tons (932,101). Germany, with a little over 3 million tons, and France, with barely 1½ million

tons, hardly rank as serious competitors.

The *rate* of recent progress is demonstrated a little more clearly by Figs. 4 and 5, which show, to a larger scale, the shipping tonnage added to the register during each of the last dozen years—in the first case representing the gross addition, and in the second case, the net addition after deducting losses due to wreck. It will be noticed that only in 1908 was the British figure exceeded, and then, during a period of depression in shipbuilding from which there has been a rapid recovery. Although the figures for the United States in this connection appear at times to indicate vigorous competition, it must be remembered that they include the tonnage of canal boats and barges, which it is impossible to separate in the Board of Trade return from which the information is taken.

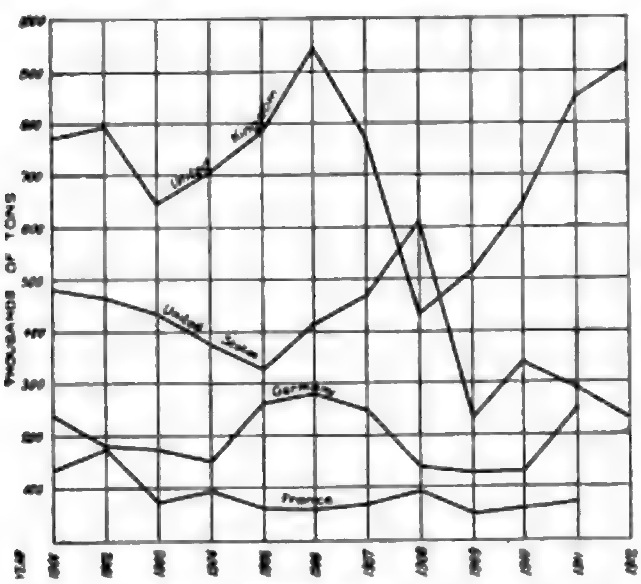



FIG. 4.—DIAGRAM SHOWING TONNAGE OF SAILING AND STEAM VESSELS ADDED TO THE MERCHANT NAVIES OF THE PRINCIPAL MARITIME COUNTRIES FROM 1901-1912.

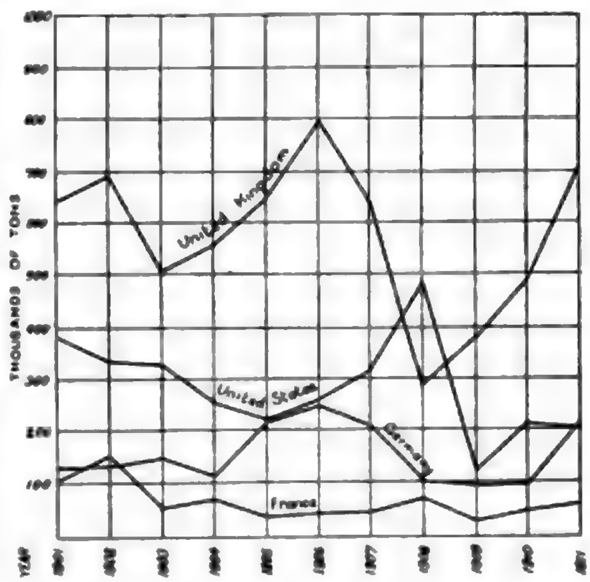



FIG. 5.—DIAGRAM AS IN FIG. 3 BUT AFTER DEDUCTING TONNAGE OF VESSELS REMOVED FROM REGISTER ON ACCOUNT OF WRECK.

As to how far these two competing nations supply their needs from their own shipbuilding yards, the historical review comprised in Fig. 3, extending back as far as the year 1870, shows that, generally speaking, each country is adequately equipped for the purpose, and further gives definite evidence of the superior activity of British builders. At no time, except during the year 1908 already mentioned, has the United States' output exceeded the British output, and the qualification in regard to the nature of the vessels constructed is equally applicable in this more extended comparison. The United States is very largely self-contained, and the major portion of her trade lies along rivers, canals and inland lakes. Her interests overseas are not great, and the necessity for building vessels of large tonnage is therefore relatively slight.

The general status of each shipbuilding country in the world in reference to the total output for last year is given in the following table, showing number and tonnage of all vessels of 100 tons and upwards, built by each of the several countries of the world during 1912, as recorded in Lloyd's Register Book:—

| | No. | Tonnage. |
|---|---|---|
| United Kingdom .. | 629 | 1,661,867 |
| British Colonies .. | 36 | 14,680 |
| United States of America .. .. | 100 | 171,468 |
| Austria-Hungary .. | 10 | 56,580 |
| Denmark .. .. | 23 | 30,946 |
| France .. .. | 66 | 151,353 |
| Germany .. .. | 118 | 352,562 |
| Holland and Belgium | 76 | 103,880 |
| Italy .. .. | 23 | 23,440 |
| Japan .. .. | 72 | 40,996 |
| Norway .. .. | 89 | 49,481 |
| Russia .. .. | 11 | 12,152 |
| Sweden .. .. | 18 | 10,905 |
| Other countries .. | 7 | 7,996 |
| Total .. .. | 1,278 | 2,688,306 |

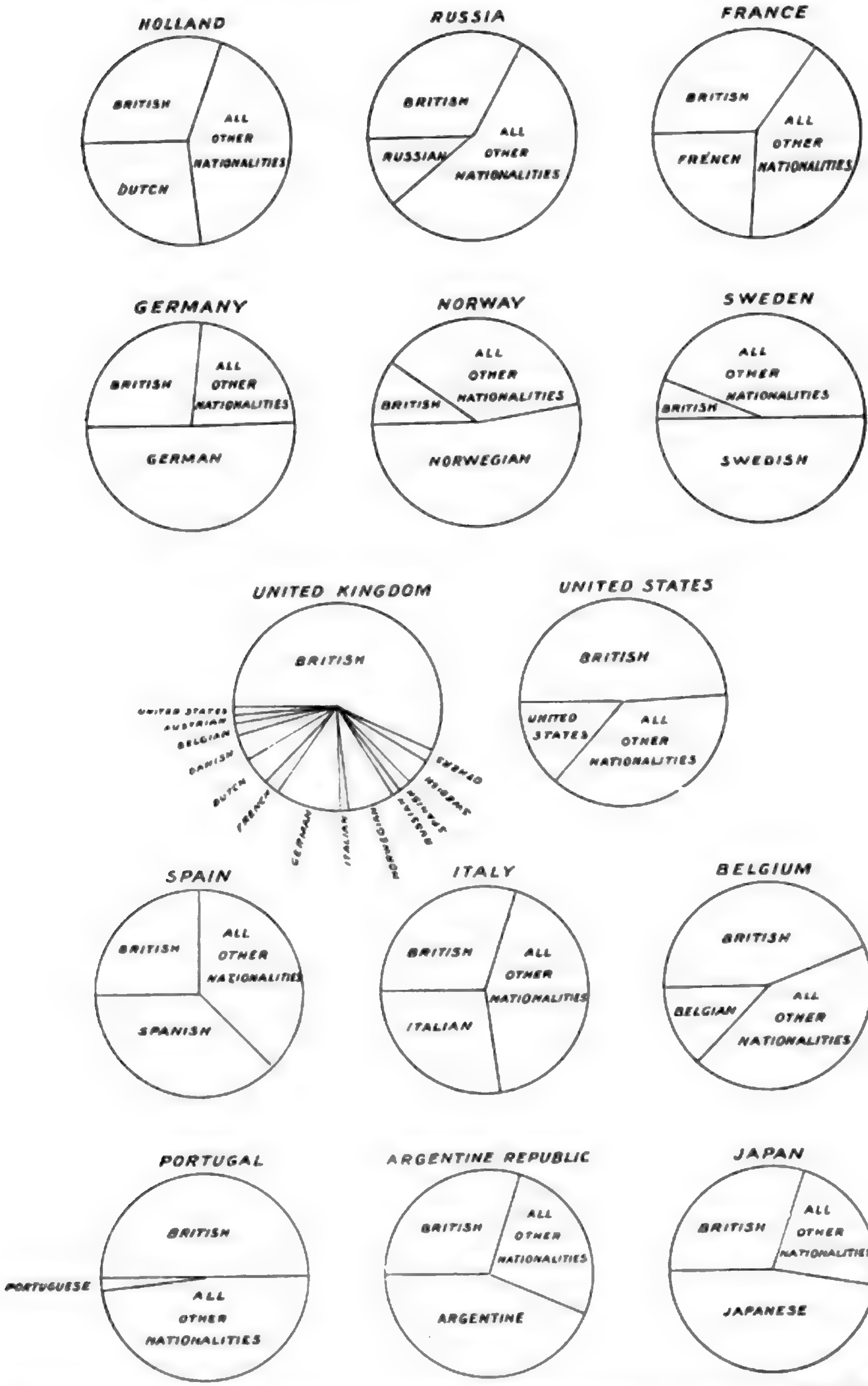



FIG. 6.—SHOWING PROPORTION OF EACH COUNTRY'S TRADE CARRIED BY ITS OWN OR OTHER NATIONS' SHIPPING.

Our survey now goes on to take into account the extent to which each maritime nation carries on its oversea trade by means of its own shipping, or of that flying the flag of some other nationality, and to illustrate this aspect of our enquiry the series of diagrams in Fig. 6 has been prepared. Taking in each case a circle to represent the total tonnage of all vessels entered and cleared, with cargoes and in ballast, in the foreign trade of the country represented, the sub-divisional sectors indicate the percentage proportion flying the national, the British, and all other flags.

It will be seen that Great Britain has a larger proportion of her trade in her own hands than any of the other countries have of their trade in their hands. Not only so, but she is in possession of a moiety of the foreign trade of the United States and of Portugal, and almost as much of that of Belgium. In regard to Holland, Russia, France, Italy, the Argentine Republic and Japan, the British share is one-third; in regard to Germany and Spain, it is one-fourth, and only in the case of Norway and Sweden does the proportion fall below this standard. These figures are really remarkable, especially when it is considered how small a proportion of British trade the competing nations have been able to secure in return.

But now we may ask, how do these diagrams compare with the diagrams which were prepared nine years ago for the article in CASSIER'S, already referred to? Placing the pages in juxtaposition, we cannot but admit that the British proportion has shrunk a little almost all round—very slightly in regard to Germany, Norway, Sweden, the United States, France and Portugal, but perceptibly in regard to Russia and Holland. On the other hand, the situation in regard to Belgian trade is unchanged, in Spanish trade there has been a small gain, while in Italian trade the percentage has risen from 20½ to 29 per cent. of the whole.

Of course, there is an explanation of this apparently retrogressive movement which must not be overlooked. The trade of a country grows, and with it the national shipping. It could hardly be expected that Great Britain should maintain a *pro rata* increase in the trade of each of the countries of the world. Take Germany, for instance, whose foreign trade as expressed in shipping tonnage has risen from 31 millions in 1902 to 49½ millions in 1911. The national flag controls practically the same percentage and the British proportion has declined some 2 per cent. Seeing, however, that the British tonnage has actually increased from less than 7 million tons to over 12 million tons—nearly doubling itself, in fact—it cannot be claimed that there is anything but a very satisfactory growth, and that the slight reduction in percentage is an almost inevitable concomitant of the intensity of modern competition.

The total tonnage engaged in the foreign trade of the United Kingdom in the year 1911, was 139 millions, of which over 81 millions was British owned. The aggregate tonnage of the principal maritime countries of the world (excluding Great Britain) was less than 540 millions, and only about 150 millions of this flew the respective national flags. Let us add that the returns for 1912 (not yet available in the case of foreign nations) show that the British total has risen to 152½ million tons, of which nearly 89 millions is British owned.

There is, therefore, no ground for drawing pessimistic conclusions. The end of the British supremacy in the mercantile marine is not yet. Her lion's share of the world's trade is on the whole fairly maintained, and the enterprise which characterises the present policy of British shipowners and Oversea traders augurs favourably for the future. A final glance at Fig. 2 should produce a feeling of expectation, if not of conviction, that the upward line of advance which has been so consistently maintained during the past 72 years will be continued for a long time to come.

# THE RESOURCES OF TASMANIA

ITS INDUSTRIAL AND AGRICULTURAL DEVELOPMENT

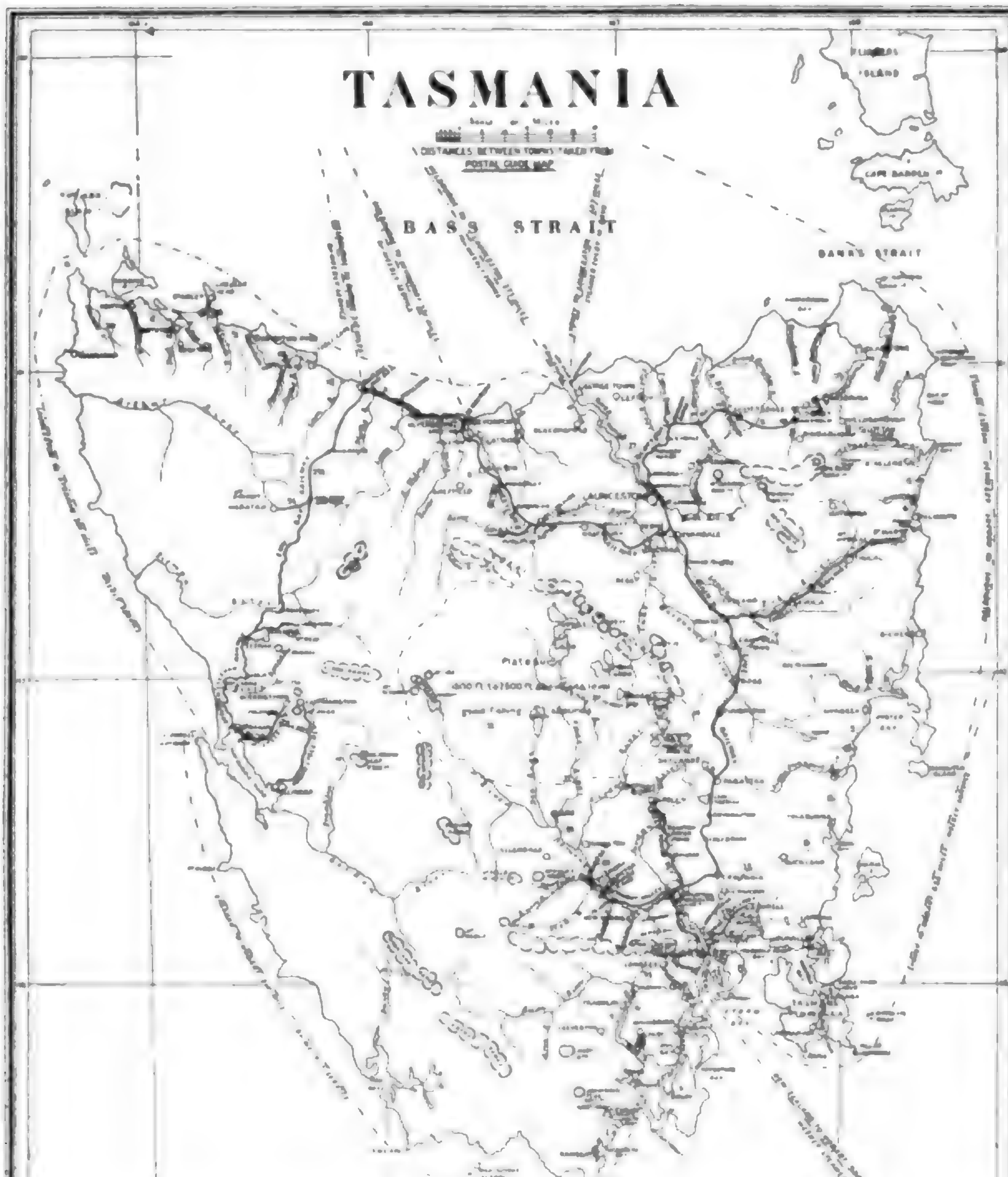
**By W. Wilson, B.E.**

IN nearly every characteristic Tasmania differs from the rest of Australia. It is by far the least populous of all the States, having only 190,000 inhabitants for its 26,215 square miles, giving a density of 7. But almost the whole of its territory is well watered and useful. It is a land of running streams, with rivers and lakes in abundance. The climate is the most in accordance with European ideas of perfection, and it attracts numbers of invalids and retired officials from other countries, notably India. The death-rate on account of this is somewhat higher than the Northern States, being 11·35 per 1,000, which seems small, however, in comparison with the rates of 14 to 30 for European countries. Plant life flourishes luxuriantly, and the general aspect is one of great green slopes, and grassy plains, relieved by the bright colouring of flowers. The soil is fertile, water power is abundant, and mineral deposits are plentiful. There seems nothing lacking to secure for Tasmania a prosperous and a brilliant future.

Yet this, the Paradise of Australia, is easily the most backward of all the States. Although founded in 1803, with an extent equal to that of Scotland, its development has been comparatively slow. The harbours are unusually plentiful and good, notably those of Hobart and Launceston, the principal towns. But the island has been overshadowed by the great size of its neighbouring states, and the stream of population and commerce has not come its way as its attractiveness would have led us to expect. Railways, though good and serving the chief districts, only total 625 miles in length, while on account of the small population, and a certain easy-going characteristic noticeable throughout the country, the various resources, such as the abundant water power, are not developed to anything approaching their full capacity.

In its natural state Tasmania was a land of rolling hills, interspersed with numerous valleys, small and large, each containing its stream, and the whole covered with dense forest. The latter was of benefit to the settlers, in that it supplied them with the splendid timber resources for which the State is famous, but was a positive drawback in that it prevented the land from being used for any other purpose until the "bush" had all been cleared off. It is even difficult to tell of what use a given locality will be till the clearing is done, while of course the thick covering enormously impedes the search for minerals. As a great p rtion of the land is still uncleared, while much is actually unexplored, it will be seen that there is wide scope for future developments.

The chief part as yet unknown lies in the south-west. Here the country is rugged and mountainous, and still covered with primeval timber. Starting from the prominent inlet known as Port Macquarie, half-way down the West Coast, to the county of Cumberland on the East, and to the South Coast as far as the South Cape, this tract includes nearly one-fifth of the whole State. It comprises most of the counties of Franklin, Montgomery, Arthur and Kent. The former contains a limited amount of agricultural land in its 1,007,700 acres, but most of it is mountainous, with peaks approaching 5,000 feet in height. It is known to be mineral bearing—in fact, it adjoins the highly metalliferous country of Montague, where the big mines of Mount Lyell, Zeehan, Dundas, etc., are situated




and the country is of the same nature and geological description. But although gold and silver-lead were discovered there years ago, prospecting has been hitherto so arduous and costly that very little indeed has been done in the direction of development. Montgomery, containing 506,000 acres, is much more low lying, the highest mountains being less than 1,500 feet in height. Arthur contains 816,000 acres, and is more mountainous, reaching 3,700 ft. Along its fringe very valuable timber has been cut. Gold, silver, copper and tin have been found there. Recently a track has been cut right through this county to Port Davey, and will make the task of prospectors a much easier one. Kent contains 820,000 acres, of which only the western half is

unexplored. Good timber is being worked on the outskirts, while gold and copper are known to exist. Excellent agricultural land, at present inaccessible, has also been found.

Tasmania may be divided into definite regions with regard to the prevalent resources. The mining country which has already been referred to as lying to the immediate north of the little known track, is the chief mineral district in Tasmania. It is situated in the Counties of Montague and Russell, where the Mount Lyell and the Mount Bischoff mines produce copper and tin respectively. The North-eastern portion of the State also produces valuable minerals, the chief being tin, gold and coal. Agriculture flourishes in the non-mineral lands of the North-west, and North-east. The South-east is mainly a pastoral district, with flourishing orchards in the principal valleys. An elevated plateau occupies the heart of the Island, comprising much of Cumberland, Westmoreland and Lincoln. Here are situated the great lakes which will some day be utilised for power generation on a large scale. Sheep and cattle breeding is the staple industry here. Uncleared land scattered in all parts of the State is supplying timber.

After this brief survey of the State as a whole, the various industries will now be considered in detail. The production of minerals rank highest in the list, and accounts for nearly half the total exports. In spite of the incompletely developed condition of the mining areas, Tasmania has an amount of proved mineral resources, in proportion to its size, possessed by very few countries indeed. The following table gives the quantities and value of the chief minerals raised during the twelve months ending on June 30th, 1912:—

| | | £ |
|---|---|---|
| Gold, ozs. .. | 34 483,151 | 146,475 |
| Silver-lead ore, tons | 87,066,295 | 326,233 |
| Blister copper, tons | 4,536 | 334,836 |
| Copper and copper ore, tons .. | 1,632 | 11 515 |
| Tin ore, tons .. | 3 685,135 | 499,691 |
| Coal, tons .. .. | 55,578 | 25,530 |
| Wolfram, tons .. | 62·84 | 6 985 |
| Bismuth, tons .. | 10·84 | 4,316 |
| Osmiridium, oz. .. | 821·41 | 5,993 |
| Total .. | .. | £1,361,544 |

MOUNT LYELL CO.'S SMELTING WORKS QUEENSTOWN.

FEED FLOOR, MOUNT LYELL SMELTING WORKS, QUEENSTOWN.

The industry is of comparatively recent origin. Gold was the first to appear, being discovered in payable quantities in 1852. Tin followed in 1871, then silver-lead in 1882, while it was not till 1893 that the Mount Lyell Co. erected their first smelter for treating copper. When the great gold rush took place to the mainland of Australia, in the early days, the Tasmanian workings, which were never of so sensational a character, suffered extensive desertions at each fresh discovery, and this proved a severe handicap to the growth of the industry. However, this state of things came to an end, and till 1907 great prosperity ensued. Since that date there has been a slight falling off in the production of most of the minerals.

It is in the western portion of the state that the richest mines occur. On this coast a strip comprising nearly a third of the whole island is composed of schists and associated rocks of pre-carboniferous age, consisting for the most part of narrow belts of rock, extending for considerable distances, each bearing its own minerals. Through them intrusive granites and porphyries have penetrated, and these are usually rich in tin. Thus, within a brief radius a wide variety of products is found, a condition distinctive of Tasmania among the Australian States.

The mines of the northern half of this strip, which alone has been prospected, lie on two lines of railways, stretching in a northerly and north-westerly direction respectively from Strahan, on the shores of Macquarie Harbour. The former extends to the port of Burnie, on the North-west Coast, a distance of 180 miles in all. The latter is a two-branched local line serving the Mount Lyell district. Zeehan, 30 miles from the sea on the northern line, is the centre of the mining industry in this part of the country. It possesses a School of Mines and is connected by rail or by tramway with most of the mines, which send their ore to Zeehan for smelting. At Roseberry, about 25 miles further north, smelters are also being erected. Williamsford, Dundas, Gormanstown and Queenstown are among the chief mining towns of this district, from which an astonishing variety of metals are derived, the

chief being copper, lead, gold, silver, tin and zinc.

The famous Mount Lyell Mine, one of the most successful in the world, comes first with an output to date as follows :—

| | £ |
|---|---|
| Gold .. .. .. | 1,285,439 |
| Silver .. .. .. | 1,149,101 |
| Copper .. .. .. | 6,530,882 |
| Total .. .. | £8,965,422 |

The chief shaft is on a spur of Mount Lyell, near Gormanstown, but its smelting works and shops are at Queenstown, about two miles distant. For ten years after the discovery of the mine, gold and a little silver only were obtained, by the crudest methods. But about 1890 big masses of copper pyrites interspersed with native copper were discovered. In 1893 this deposit was attacked, and henceforward became the chief product of Mount Lyell. Its late discovery was due to the action of the heavy rainfall in washing away every trace of copper from the outcrops. The average constituency of typical ore samples is :—

| | |
|---|---|
| Iron .. .. .. | 40·30 |
| Silica .. .. .. | 4·42 |
| Barium sulphate .. | 2·50 |
| Copper .. .. | 2·35 |
| Alumina .. .. | 2·04 |
| Sulphur .. .. | 48·50 |
| | 100·01 |

Besides the big mine, five other leases have been acquired by the company, and more recently they have amalgamated with the North Mt. Lyell Co. The treatment process is simple, and the small amount of flux required is all obtained on the spot. First of all, the copper, silver, and gold contents are concentrated into a matte, and this is reduced to blister copper in a Bessemer converter. The material is then shipped to Mt. Kembla, N.S.W., where the Electrolytic Refining and Smelting Company extract the gold and silver.

The total State output of copper for the year 1910-11 was £560,699 in value, but only £346,351 for 1911-12, a strike at Mt. Lyell causing a falling off of £200,000. Besides this field, that of Mt. Balfour, some 45 miles to the north, is the only other of any magnitude. Here ore valued at £22,840 was produced in 1911-12. However, as copper pyrites is so hard to detect in Tasmania, other valuable deposits are almost certain to be hidden in the unknown regions, awaiting discovery.

It must be realised, too, that in this region, which is so covered with tough and matted vegetation that explorers must clear every step with the axe, lodes can only be located on the very tops of the hills, or in rare exposed spots. Roads are expensive, almost as much so, in fact, as railways, and in consequence the mining companies have built narrow-gauge lines to traverse country which would be impossible for bullock waggons. For example, the North-East Dundas Tramway, although equipped with 45-ton engines, employs only a 24-inch gauge and curves of 2 ft. radius. The Mt. Lyell Co., in their private line, use the Abt system to good effect. Thus the difficulties imposed by nature are being overcome.

Tin is found extensively throughout the same district, for example, there are alluvial tin workings at North Dundas and mines at Heemskirk. But the greatest producer is the Mt. Bischoff mine, about half-way between Zeehan and Burnie, which out of a total for the State of 3,953 tons, worth £499,691, contributed 1,100 tons. Other noted producers are the Pioneer, 573 tons; Briseis, 547 tons; Anchor, 194 tons; Mt. Bischoff Extended, 181 tons; Renison Bell, 130 tons; and Arba, 116 tons. There are also numerous smaller properties, largely in the North-eastern district, where the same formation crops out as that in the west. The big mine began its career as a bitter disappointment, for the prospectors had high hopes of having secured a silver deposit. However, the softness of the button obtained by the assayer proved this to be a fallacy. Forty-two years have passed since that time, and the less precious metal has brought a total sum of £2,323,500 into the pockets of the patrons, derived from 71,300 tons of tin. The workings consist of a series

of open cuts on the flank of the mountain. Many of the smaller supplies of tin are obtained alluvially, from the remains of ancient river-beds. These are mainly in the north-eastern district. Here are the Briseis, Arba, Pioneer, Derby, Branxholm, Mt. Cameron, Mt. Horror, Moorina, Weldborough, Gladstone, Blue Tier, &c. The Anchor mine at Lottah is an example of lode-mining, and is equipped with a 100-stamp battery.

The Tasmania gold mine is the chief gold producer, and is situated in a fruit and agricultural district, near the mouth of the Tamar 960,705 tons of quartz have been treated to date, giving 786,187 oz. of gold, valued at £3,062,939. During the last few years the ore has been poor, but the mine is now being opened up at a 1,500 ft. level, and ore containing 2¼ oz. to the ton is being raised. Last year the value of the product was £92,478. Two other mines are working in the same district, the North Tasmania and the Bonanza, with encouraging prospects. The latter has already sunk to a depth of 1,180 feet. Deep level mining proved a failure at Lefroy, on the opposite side of the river, where some mines were sunk to a depth of 1,300 or 1,400 feet without result. Less than 100 oz. of gold was extracted in this field during the past year, a great falling off from the once prosperous past. There is a deep alluvial lead cutting across the lines of lode which should contain much derivative metal. However, no work has been done on it. Most of the remaining gold comes from mixed ores, such as that at Mt. Lyell, the Hercules, and other West Coast mines. Alluvial and dredging claims are also being worked. Large quantities have been obtained in the past from the Lyndurst gold field, to the east of Lefroy. Here the Mathinna mine, reaching 1,900 feet, has produced nearly £900,000 worth. Other deposits are at Woody Hills, May, and Lake Jukes on the West Coast. Loose gold is found on the flanks of Mt. Darwin, and so far its source has not been discovered. The Government are now encouraging prospecting by special grants for the purpose.

Silver-lead is being increasingly worked in West Coast mines. The

BRISEIS TIN MINE, DERBY.

THE MINING CENTRE OF ZEEHAN.

chief producing districts are:—Dundas, £99,649; Zeehan, £54,106; Mt. Farrell, £24,804; Roseberry, £17,346; and North Pieman, £3,595. Zinc-lead and copper sulphides are worked at the Hercules Mine, at Mt. Read, and also at Rosebery. At Mt. Read there are large quantities of complex sulphides containing copper, lead, zinc, gold and silver, but although separately the metals would be worth millions of pounds, yet so difficult is the separation at present that the process would entail more expense than the constituents are worth. There is a solid mass of ore opened up, measuring 800 feet by 80 feet, which would yield many fortunes to the men who succeeded in solving the problem of economical extraction.

Coal mining is not prosecuted vigorously in Tasmania, although there are abundant seams ranging from 20 inches to 12 feet in thickness. They occur in the basin of the Mersey and in the eastern district. Eleven collieries in all are at work, producing last year 57,000 tons, most of which came from the Cornwall and Mt. Nicholas Mines. The quality, however, is not equal to that of coal imported from the mainland, over 100,000 tons of which are brought over per year. Hydro-electric power is being increasingly used, and is materially lessening the demand.

Oil-bearing shale (Tasmanite) exists in enormous quantities between Latrobe, in the middle of the north coast, and Railton. Many millions of tons are available for the production of fuel oil, petrol and turps, and a company has recently begun operations here.

Extensive deposits which will be of great value in the future are those of iron ore, notably at Penguin and the Blythe River, both on the north-west coast within ten miles of Vurnie, and also near Beaconsfield on the Tamar. The ore consists of a very pure hæmatite, containing, besides ferric oxide, only traces of phosphoric acid, silver, copper and gold. The English engineer engaged to report on the deposit at the Blythe, estimated that, for twenty years at least, 150,000 tons could be produced annually from this mine alone. The Penguin Mine is supplying ore to smelting companies in New

South Wales, but the other sources will only be made available after the country is opened up.

Minerals worked in smaller quantities include :—Iron pyrites, exported by the Mt. Lyell Co. for the manufacture of sulphuric acid, over 9,000 tons, value £3,595 ; osmiridium (used in the industrial arts, *e.g.*, for tips of fountain pens), 821 ozs. from the Savage River district, near Mt. Bischoff, value £5,963 ; wolfram, £6,985 ; and bismuth £4,316. Hydraulic limestone of good quality occurs at Maria Island, off the East Coast ; while Portland cement works are about to be started at Schouten Island, a little north of the last-named.

Building stones are being quarried in various parts of the island. These include sandstones and limestones. There are also numerous deposits of clay for brick-making and for fine pottery.

Turning now to the above ground resources, the first product of the soil was the timber found in its natural state by the settlers on their arrival. Nature is favourable in Tasmania to the growth of forests, and as we should expect, this asset is a valuable one, and the distinctive character of most of the timbers makes it still more so. There are, it is true, three varieties of pine—Huon, Celery-top, and King William—the supply of which is nearly all used up locally. But it is the hard wood timbers (eucalypti) that have made the country known to the world as a timber producer. Of this genus there are about 18 distinct species, of which the chief are the gigantic eucalyptus globulus, or blue gum, and eucalyptus obliqua, commonly known as stringy bark. The former is confined to the south of the island, while the latter is grown generally in all parts. They are magnificent trees, of 350 feet in height, twenty feet in circumference, three feet from the ground, with a clean barrel of 250 feet to the first limb, and containing upwards of 25,000 superficial feet of marketable timber. They are very strong and heavy (E. obliqua being the lighter), greyish in colour, and are used where strength and durability are required, as in shipbuilding, wharf-constructing, railway-sleepers, paving blocks, and agricultural implements. They take a good polish, and stringy bark, especially, is commonly used for wainscotting. The young wood is tough, stringy, and

A TIMBER TRAIN AT GEEVESTON.

elastic, and is used for cart-shafts, spokes, &c. Piles can be supplied 100 feet in length, and have an extremely long life. Large quantities of 18 by 18 and 20 by 20 piles were exported for the Dover Harbour Works, England, ranging from 80 to 100 feet in length. Shipments are also made to India, South Africa and Eastern Ports. The strength, as given by $B = \frac{L.W.}{4\ bd^2}$, lies between the limits of 1,800 and 3,600, and the specific gravity is from ·84 to 1·09 for blue gum, and ·75 to 1·04 for stringy bark. It is from the leaves of the blue-gum that the famous eucalyptus essence or oil is distilled.

Other species are the Peppermint (E. amygdalina), whose characteristic quality is its stiffness, adapting it for posts and roofing, as well as shipbuilding; swamp-gum (E. regnaus), open and free in the grain, with a specific gravity of between ·77 and ·85, useful for flooring and fruit cases; white-gum (E. viminalis), which is still lighter, s.g. ·7 to ·76, used mainly for internal woodwork; and ironbark (E. sieberiana), a reddish timber obtained from smaller trees, but with the same qualities as blue-gum and stringy-bark.

Beside the Eucalypti, many timbers with varying characteristics are found in large quantities. The most valuable of the fine grained woods is probably the Blackwood (Acacia melanoxylon). It is of remarkable versatility, being employed for a wide range of purposes which include the manufacture of furniture, panelling for railway carriages, bannisters, and interior fittings generally, billiard tables (for which its complete fitness has been well established), and for cooperage, a use that its soundness and durability render wholly suitable. In appearance and colour it strongly resembles cedar. Huon Pine (Dacrydium franklinii) is straight grained, and of a bright yellowish colour, and often handsomely figured. This has been referred to by eminent authorities as one of the best timbers in the world. There are few, if any, better woods for general boatbuilding. It possesses, among other good features, an unusual immunity from the attacks of borers, probably on account of its resinous nature. Railway cars and waggons, and cabinet work are among its most appropriate uses. Myrtle (Fagus cunninghami) often exceeds 100 feet in height, and resembles English ash in character, but is of greater strength (B = 2712 to 2804). Its colour is a light pinkish-brown, with a variety that is nearly white. Celerytop Pine (Phyllocludus rhomboidalis) is tough and heavy, does not shrink or warp, and is therefore suitable for spars and decking of vessels, as well as boarding generally. King William Pine (Athrotaxis cupressoides) is very light (s.g. = ·336 to ·385), yet tough and durable. Ironwood (Notelea ligusatrina) is similar to lignum vitae. A large number of ornamental woods are also plentiful.

With regard to the locality and extent of the timber beds, the hardwood forests at present known cover the whole explored portion of the county of Kent, much of the county of Buckingham, Tasman's Peninsula, Forestier's Peninsula, and South Bruni Island, all in the south-east, part of the adjoining county of Pembroke, all the country along the West and the North-west coasts, and much of the North-eastern counties of Dorset and Cornwall. All the timbers mentioned are common, though the hardwoods alone are sufficiently plentiful to permit a big export trade. There are about 90 or 100 sawmills at work in various parts of the State.

Where naturally occurring trees flourish in such profusion, it is only to be expected that those planted artificially should share the same good fortune. Accordingly we find that fruit-growing is a most prosperous industry, and one to which Tasmania looks for one of her chief sources of revenue in the near future. Stringybark land is especially suited for orchards, as are many tracts of country rated as second-class agricultural land, which possess a clay subsoil at no very great depth. The latter soils, as has been discovered only of recent years, yield actually a better return than the

ORCHARD CULTIVATION AT BAY VIEW, RIVER TAMAR.

so-called first-class land. At present this industry is increasing very rapidly many of the orchards in existence being only from 3 to 7 years old, and not in full bearing. The valley of the Tamar, and the country round Launceston are covered with young fruit gardens, growing in a light loamy soil over clay. In all directions fresh trees are being planted here, and the prospects of the district appear brilliant. The valley of the Derwent, near Hobart, is also thick with orchards, and 20 miles north of Hobart the Bagdad valley has changed from being a famous wheat growing locality to a more famous fruit district. The Huron and Derwent valleys are other instances of the same change. There is a great abundance of suitable land available at 10s. to 20s. per acre. Clearing costs from £5 10s. to £18 per acre, ploughing 15s. to 20s., per acre, and fencing about 9s. per chain. Thus the total cost of a 25 acre apple-farm for the first five years, including interest at 5 per cent., is about £2,000. From the fifth to the seventh year the returns pay expenses, and during the next three the yield rapidly increases, till after the tenth year it amounts to at least 6,000 bushels. This crop, at the moderate rate of 2s. 6d. on the trees, produces £750. It will be seen, therefore, that provided the market remains good, this industry will be both prosperous and prolific. Last year 2,248 additional acres were planted with fruit, and the production increased by 157,992 bushels. In 1911 the total acreages devoted to the growing of the various fruits, without including the less important centres, were as follows:—

| | Acres. |
|---|---|
| Apples | 20,412 |
| Pears | 3,090 |
| Apricots | 1,465 |
| Plums | 1,254 |
| Cherries | 720 |
| Peaches | 246 |
| Raspberries | 1,168 |
| Gooseberries | 340 |
| Strawberries | 122 |
| Currants | 548 |
| | 29,365 |

The yield of apples alone was 1,480,107 bushels, and of pears 94,425 bushels. All varieties of English fruits flourish, and nearly all are grown in quantity. Raspberries and gooseberries are grown on the slopes of Mt. Wellington, overlooking Hobart, at a height of 1,700 feet. Hops also thrive. They were grown on 1,639 acres, and the yield was 1,775,276 lb., valued at 110,954. Much of the fruit is turned locally into jam, jelly, preserves or pulp; 17,595,065 lb. in all were so produced, worth £202,169.

Cultivated land in 1910 totalled 5,396,117 acres, of which 274,026 acres were under crop, and 491,423 acres were pasture. Much of the country is admirably suited for crops, especially in the basaltic districts of the North-east and North-west coasts, where the soil is very fertile and the rainfall from 36 inches to 43 inches per annum. The extent and value of this industry may be estimated from the following figures for 1910-11 :—

| Product | Acreage. | Total Yield. Bushels. | Average Yield. Bushels. |
|---|---|---|---|
| Wheat .. | 52,242 | 1,120,744 | 21·45 |
| Barley .. | 5,235 | 142,318 | 26·68 |
| Oats .. | 63,887 | 2,063,303 | 32·29 |
| Rye .. | 1,261 | 23,255 | 18·44 |
| Peas .. | 19,727 | 492,972 | 24·98 |
| Beans .. | 314 | 5,433 | 17·30 |
| Flax, &c. | 566 | 13,191 | 23·11 |
| | | Tons. | Tons. |
| Potatoes .. | 26,230 | 70,090 | 2·67 |
| Turnips .. | 3,743 | 48,463 | 12·94 |
| Mangel-wurzel .. | 1,799 | 35,941 | 19·98 |
| Carrots .. | 218 | 2,749 | 12·61 |
| Onions .. | 62 | 328 | 5·29 |
| Hay .. | 72,992 | 115,190 | 1·58 |

Pigs, poultry and bees all thrive well, and are conveniently worked in conjunction with the farms.

Apart from the first-class agricultural land, there is a second-class of soil that has given better results quite lately upon an investigation of its composition. This is the light soil with clay sub-soil which has already been referred to as highly suited for fruit-growing. It was found that the clay was in a non-flocculated condition, in which it can remain suspended in water for a long period. It is therefore easily washed away by rain, or carried down into the soil. This can be obviated by the addition of lime, and hence a considerable improvement has been effected. Systematic experiment upon these Tasmanian soils should much extend the agricultural areas. Unfortunately, system and co-operation are two qualities which are somewhat lacking among the present agriculturalists. Many fertile tracts are lying idle, also, because their chilly nature renders special methods of cultivation necessary.

Unlike the mainland, the Island State does not possess vast tracts of grazing country capable of supporting enormous flocks of sheep. This usual Colonial industry is therefore rather in the background. There is no mutton export—in fact, at one period of the year both sheep and cattle are actually imported for slaughtering purposes. But stud sheep are bred and exported in considerable numbers. Tasmanian Merinos have a high reputation, and these rams have secured prices of £1,000 and more. Recently the breeding of Shropshires has been similarly undertaken with excellent results, and Lincolns, Leicesters, Southdowns, and other breeds also do exceedingly well. The absence of droughts, and the possession of every condition necessary for the purpose, make Tasmania an ideal place for such an industry. The following are the numbers and value of the sheep exported to the mainland in various years :—

| Year. | Number. | Value. |
|---|---|---|
| 1871 | 998 | £4,666 |
| 1891 | 6,591 | £74,895 |
| 1906 | 9,804 | £50,232 |
| 1871–1906 | 153,366 | £1,350,132 |

The total amount of live stock for 1912 is as follows :—

| | |
|---|---|
| Horses .. .. .. | 41,853 |
| Dairy cows .. .. | 56,858 |
| All other .. .. | 160,548 |
| Sheep .. .. | 1,823,017 |
| Pigs .. .. .. | 67,392 |
| Goats .. .. | 2,527 |
| Total .. .. | 2,152,195 |

LAUNCESTON, TASMANIA, SHOWING UPPER REACH OF RIVER TAMAR.

Water-power resources are particularly great Running streams exist all over the country, while in the tablelands of the interior lakes are very numerous. Little has been done towards utilising the power as yet. Launceston, however, developes a total of 1,200 K W. from the Cataract Gorge, near the city, which is used to operate tramways, as well as to supply power and light. Current is retailed at 6d. to 1½d. per unit for lighting, and 2d. to ½d. for power. Deloraine and Latrobe also have hydraulic installations. The Hydro-electric Power and Metallurgical Co., Ltd., are at present erecting a power-house at the outfall from the great lake, to develop 9,000 H.P., by means of two Boving turbines, as a first instalment. Current is to be generated at 88,000 volts, 3 phase, and will be transmitted 64 miles to Hobart. A site for an electrolytic smelting plant has been obtained at North-west Bay, and metallic zinc, calcium, carbide and cyanimide, and perhaps aluminium will be produced. The Mt. Lyell Co. are installing a plant at Lake Margaret to supply power in large quantity for their smelting and other operations, and also for the municipality of Queenstown.

It will have been gathered that Tasmania, though a country eminently suited for the white man and his civilisation, suffers at the present time from lack of development and organisation. It is true that the opening of the bush-covered territory is a difficult task, but this is not a complete explanation of the backwardness of the country. The very pleasant climate has probably to be blamed for making life too agreeable; but at any rate the country has undoubtedly valuable resources, and hence is a field where enterprise can earn big dividends.

# THE CONSTRUCTION OF STEAM TURBINES

PART II

SOME TURBINES OF BRITISH MAKERS.

By B. Schapira

*Part I. of this article appeared in the November Issue. Part III. which will appear in the January issue will deal with the Steam Turbine in the United States.*

MESSRS. C. A. PARSONS & CO., LIMITED, of Newcastle-on-Tyne, England, construct exclusively land turbines, while The Parsons Marine Steam Turbine Co.; Limited, Wallsend-on-Tyne, deal with marine propulsion. The principle of the Parsons' turbine is now so thoroughly understood that it is unnecessary to describe the same, and we will, therefore, confine ourselves to mentioning the latest improvements which Messrs. Parsons have introduced.

Parsons' standard blading is composed of brass, which is drawn and rolled to the required section and polished so as to minimise, as far as possible, steam friction. In the high-pressure expansions the blades are generally formed of pure copper, which has been found by experience to be the most suitable metal for standing superheated steam. Two methods of securing the blades are in regular use by the Parsons' firms, the first being known as the individual caulking system, and the second as the threaded root or rosary system. In the first system the blades and distance pieces are cut to length and placed alternately in the serrated groove machined in the turbine shaft, the final fixing being effected by caulking the packing pieces which lie between the blades. In the second system each blade and each section or distance piece has a small hole drilled through it, through which a brass wire is threaded while the blades and sections are being assembled in a metal former of the correct radius. These assembled sectors are fixed in grooves by the usual system of caulking.

The tips of all Parsons' blades are thinned away (in a special machine), so as to present a very small area of contact should any touching take place between the shaft and the blades, or between the blades and the cylinder. The blades are strengthened by a binding strip, which is fitted into grooves cut in the side of the blade, the binding strip being attached to the blades by means of silver solder ; blades of small height have one binding strip, while in the case of very tall blades, as many as three or four binding strips are often used.

When designing for use with superheated steam Parsons invariably use cast steel for the highly heated part of the turbine cylinder, in view of the fact that experience has shown that cast iron, when subjected to high temperatures, is liable to serious growth and distortion.

Turbines for large outputs are almost invariably made on the tandem principle, each high pressure and low pressure turbine having its own separate shaft, bearing and casing, the steam passing through each turbine in series. The tandem design enables high economy co-efficients to be obtained, and at the same time it permits the use of comparatively short and stiff shafts.

The shaft of the high pressure portion of a tandem turbine is made of solid forged steel, while that of the low pressure turbine consists of either a

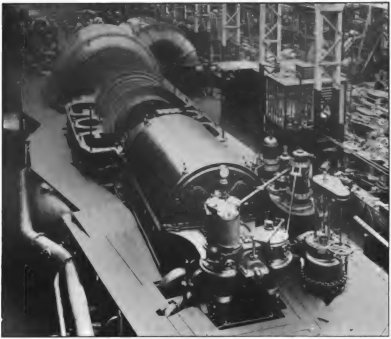


FIG. 1.—25,000 K. W. TURBO-ALTERNATOR. MESSRS. C. H. PARSONS & CO., LTD., NEWCASTLE. THE PHOTOGRAPH SHOWS PART OF ITS CASING REMOVED.

hollow tube shrunk on to supporting wheels mounted on a central shaft, or a solid forged shaft carrying a number of steel discs, each of which supports one row of blades. The governor fitted to Messrs. Parsons' turbines is of the steam operated relay type.

Parsons' turbine casings are divided horizontally, and in large cylinders there are vertical joints between the various portions of the cylinder, as well as the main horizontal joint. All cylinders are tested hydraulically to a pressure of one-and-a-half times the working pressure, and they are also subjected to a steaming process between rough boring and finish boring operations, the object of the steaming being to remove any strains which may exist in the casting as received from the foundry.

Fig. 1 illustrates the latest type of turbo-alternator, built by Messrs. C. A. Parsons and Co., Ltd. It is of 25,000 k.w. capacity, and was specially manufactured for the Commonwealth Edison Co. of Chicago.

The small turbines, constructed by Messrs. Brotherhood, Ltd., of Peterborough, England, consist of a Curtis wheel having two velocity stages. The short shaft is extremely rigid and the critical number of revolutions far exceeds the normal speed. The rotor has the well known shape of a wheel of equal strength and lowest weight, and is completely balanced. The blades, which are constructed of a special alloy, are lodged in dove-tailed shaped slots, and are covered by a shroud ring in order to stiffen them. The guide-blade rim can be taken out easily without

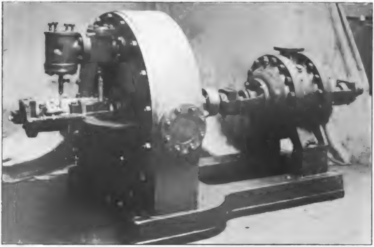


FIG. 2.—BROTHERHOOD SMALL TURBINE WITH CENTRIFUGAL PUMP.

dismantling the turbine. It is very rare for the blade ring to be damaged, as the axial clearance between the guide blades and the moving blades is at no point less than ⅛ inch. The rotor and the blades are highly polished, in order to reduce as much as possible the friction of steam ; in a like manner the conical bronze nozzles, lodged in the inside of the cover of the turbine, are polished within.

The cast iron casing is divided hori-

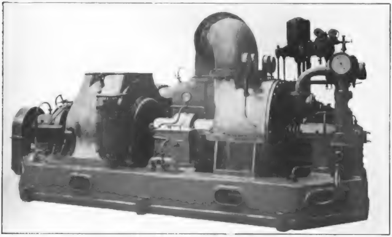


FIG. 3.—TURBO GENERATOR FOR 200 K.W. WITH CONDENSING PLANT AND PUMPS. MADE BY PETER BROTHERHOOD, LTD., PETERBOROUGH.

zontally and vertically, and is only exposed to exhaust pressure, as the steam pressure in the nozzles is reduced to the exhaust pressure. After the machining the casing is hydraulically tested and repeatedly heated and cooled off in order to discover if there are any flaws in the casing. The cast iron casing for the bearing is not connected directly to the turbine casing, with the result that the heat emanating from the casing of the turbine is not transmitted on to the bearing, thus facilitating the

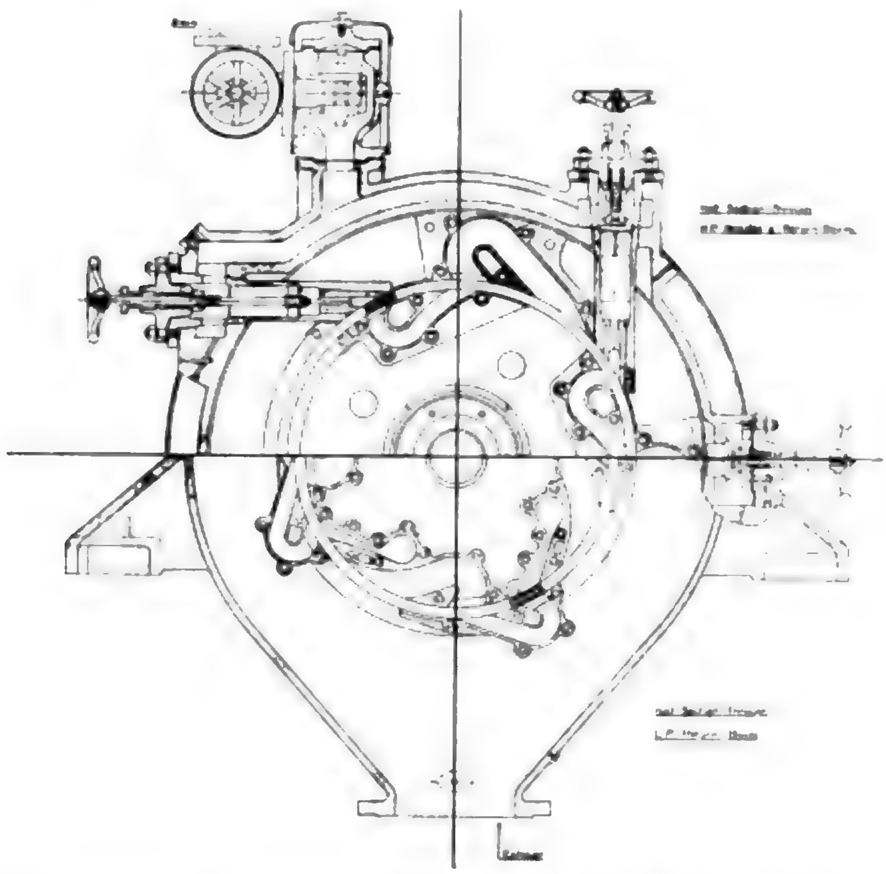


FIG. 4.—END SECTION OF TURBINE MANUFACTURED BY W. H. ALLEN, SON & CO., LTD., BEDFORD.

ubrication. As the live steam merely enters the nozzles, the blades are only exposed to a steam of low temperature, whereby again their life is increased.

The governor employed is of the fly ball type, and is driven by gearing from the turbine shaft, governing by means of a spring loaded double beat throttle valve. If it is desired to alter the speed of a turbine while it is working, it is only necessary to manipulate the valve spring by means of a hand wheel. Moreover, in the case of a continual alteration of the load, nozzles may be shut off or opened by hand. The safety stop valve is lodged in front of the regulating valve, this is closed by a spring, and is held open by means of a pawl, unless the speed of the wheel becomes excessive. As soon as the number of revolutions of the turbine exceeds the limit allowed, a spiral spring attached to the turbine shaft begins to expand, in consequence of the centrifugal force coming in contact with a trip and releasing the pawl. The gland of the turbine shaft is provided with a carbon packing. There are, furthermore, on the shaft and on each side in front of the bearings, two protective rings, which prevent any water, due to condensed steam from the gland, from entering the bearings. Figs. 2 and 3 show examples of Brotherhood turbines, the former a small turbine coupled with centrifugal pump, and the later a turbo generator of 200 k.w. capacity,

with condensing plant and pumps. Messrs. W. H. Allen, Son and Co., Ltd., of Bedford, England, construct small turbines having an output of from 5 to 600 h.p. The normal speed from out of question, and no collar bearing is required. In view of the fact that the jet of steam traverses a series of moving blades, and in each only yields a part of its speed, the peripheral

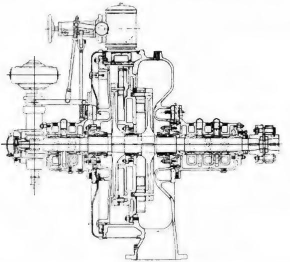


FIG. 5.—LONGITUDINAL SECTION OF ALLEN TURBINE.

5 to 20 h.p. is 3,500 r.p.m., from 20 to 100 h.p. 3,000 r.p.m., and from 100 to 600 h.p. 2,500 r.p.m. The turbine can, however, be arranged to run at a speed below the normal proportion, when, of course, the consumption of steam increases and the cost is greater in proportion compared with running at a normal speed.

The Allen turbine is an impulse turbine, consisting, according to the output and the steam pressure required, of one or two pressure stages, and working either as a non-condensing or as a condensing turbine. The steam coming from the nozzles, flows through the moving blades in a radial direction, at a speed the degree of which depends on the drop of pressure converted into speed in the nozzles. Owing to the radial direction of the flow of steam an axial pressure on the bearings is

FIG. 6.—BLADE WHEEL OF ALLEN TURBINE

velocity of the rotor can be kept low.

For very high steam pressures, or when the turbine is to work condensing,

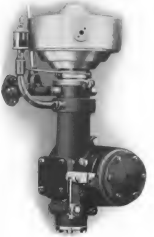


FIG. 7.—GOVERNOR OF ALLEN TURBINE.

two pressure stages are provided as Figs. 4 and 5 show, which are separated from each other by means of a gland labyrinth packing, and each of which is fitted with nozzles and return boxes, which last have an increased section in proportion to the progressive reduction in the velocity of the steam, so that in one unit of time the same quantity of steam can pass through the successive return boxes. The steam coming from the nozzles enters into the first moving blades, yields here a part of its velocity, flows into the return boxes which alter the direction of the flow, then passes on to the following moving blades of the same rotor, etc., until all the kinetic energy contained in the steam has been converted into work. No difference existing between the steam pressure in the casing and in the blades, the steam does not tend to escape along the sides of the blades, so that the clearance between the nozzles, moving blades and the return boxes may be as great as desired, and all danger of the blades touching in consequence of expansion due to heat is done away with.

The cast iron casing is divided ver-

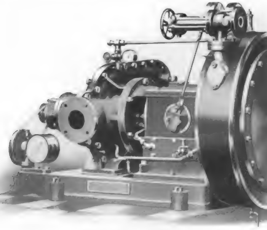


FIG. 8.—ALLEN TURBO DRIVEN PUMPING SET.

tically, and is exposed only to a slight internal pressure, and may thus be built lightly. The bearings are provided normally with ring-lubrication, and are only constructed for a forced oil lubrication for the larger sizes of turbines, in which case the oil is supplied by an oil pump driven by the turbine shaft and which is cooled by a tube-cooler. The spindle is made of high grade steel and the rotor, when completed, is balanced accurately.

The blade-wheel shown in Fig. 6 is made of special quality steel and polished in order to reduce the steam friction. The blades are constructed of a special alloy capable of withstanding the high temperature of the steam without corroding, and are fitted into the blade wheel by means of a chrome steel ring shrunk on, while the ends of the blades are stiffened by the aid of a shroud ring made of the same material. The bronze nozzles and the return boxes which are likewise of bronze are also highly polished within, in order to reduce the loss subsequent upon friction. The glands are fitted with a labyrinth packing, the rotating part of which consists of steel rings, while the stationary part is of white metal, so as not to produce any extreme heat in case of touching. At the same time, and in consequence of this, the clearance may be kept very small. The glands are fed with live steam, and if the pressure in the turbine casing is below the atmospheric pressure—which is generally the case when condensing turbines come in question—the live steam is introduced into the annular space of the stationary part of the gland in order to prevent air from entering the casing of the turbine.

The governor shown in Fig. 7 is of the centrifugal type, which controls a double beat throttle valve; in most cases an emergency governor is likewise provided, which closes a separate valve.

It is worth noting that the angle of the moving blades and reversing chambers was determined as a result of tests wherein it proved to be the most advantageous for the purpose. In the event of a constant variation of the load being desired, some of the nozzles may be closed by hand. The casing is subjected to an examination prior to its being put into use, and is heated and then again allowed to cool off several times in order to detect any flaws in the casting. The exhaust chamber is dimensioned adequately in order to exclude the possibility of any internal back pressure. As the exhaust steam is perfectly free from oil it may be

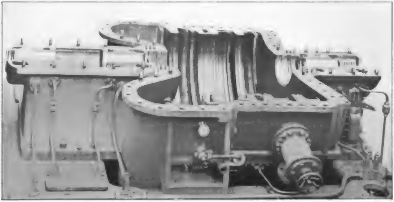


FIG. 9.—LOWER HALF OF CASING OF A 4-STAGE HIGH PRESSURE CURTIS TURBINE, BUILT BY THE BRITISH THOMSON-HOUSTON CO., LTD., RUGBY.

utilised for various industrial purposes, such as heating, etc. Fig. 8 shows a turbo driven pumping set by the same makers.

The steam turbines of the British Thomson-Houston Company, Ltd., of Rugby, England, are like those of the French Thomson-Houston Company, Curtis turbines from which they are distinguished merely in the construction of some details, and for which reason they are here dealt with separately.

metal to metal. The two bearings are supported by means of shoulders at the cover of the turbine casing, and are subjected to but slight temperatures and pressures even at the glands and the turbine casing itself, in view of the fact that the steam pressure in the admission nozzles is reduced to 25 per cent. of the boiler pressure. Fig. 9 shows the lower part of the casing of a 3,000 k.w. turbine having four stages. Each stage is formed by a Curtis wheel having several rows

FIG. 10.—HIGH PRESSURE THREE STAGE HORIZONTAL THREE PHASE CURTIS TURBO ALTERNATOR.

The bed-plate of the turbine is made of one piece, provided the conditions of casting and transport permit of this, for both turbine and generator, and is provided with a box-shaped cross section which gives it great rigidity. In the case of larger turbines the casing of the turbines is divided in a vertical direction twice. The vertical screw connections are permanent ones, and are not screwed off, while the horizontal connection must permit of a facile detaching to allow the rotor being examined at any time desired. The working surfaces are made steam tight without the use of packings merely by carefully fitting

of buckets and a diaphragm containing the nozzles. The live steam enters at the centre of the turbine casing into the admission nozzles of the first pressure stage which is formed at this point by the second wheel, while the second pressure stage is represented by the first moving wheel. After that the steam passes through an opening in the turbine casing in front of the third pressure stage, and thereupon across the fourth and five stages to the condenser. All the glands have packing against the atmospheric pressure on the side of the governor and against vacuum on the exhaust side.

The governing mechanism is of the

automatic nozzle type, as in the case of the turbines built by the French Thomson-Houston Company, from which they distinguish themselves principally by the use of the oil-servomotor. The cam shaft is driven by means of a rotating piston which is turned either to the one side or the other, according to the supply of forced oil. The cams are seated helically on the cam shaft so that the inlet valves may be opened successively one after the other. Each of these valves sends live steam to one of the sets of admission nozzles, so that the admission is always and at every moment in proportion to the load.

The turbine and the generator are each provided with two spherical bush bearings, having cast iron bushes which are fitted with white metal paddings lodged in dovetailed slots. The bearings are lubricated by means of forced oil, which is supplied by the usual kind of oil pump of the rotary gear type. Turbines having an output of less than 1,500 k.w. are likewise fitted with ring lubrication. Fig. 10 shows a high-pressure three stage turbo alternator.

On the side of the governor there is lodged a small thrust bearing of ordinary build, the rotating collars of which are turned into the shaft, while the stationary rings are made of white metal and are fitted in a cast iron casing. The lubricating oil is supplied at a 25 lb. pressure, which is maintained by means of a relief-valve. The glands are provided with carbon rings, which are composed of four parts, and which press, by means of a spring lodged at the circumference, against a sleeve fitted on to the shaft. In case of need the gland is supplied with low pressure steam for the purpose of packing.

The shaft is hammered out of good grade steel and the wheels are cast steel. The moving wheels are provided with a strong boss, which is keyed on to the shaft, and which makes it impossible for a loosening to take place while the turbine is at work, and are fitted with two slots into which, through enlarged openings, the blades of the impulse type are placed. After the blades have been fitted in, the said openings are filled by means of steel caulking pieces. The impulse blades are made of good quality bronze, and are highly polished. The stationary

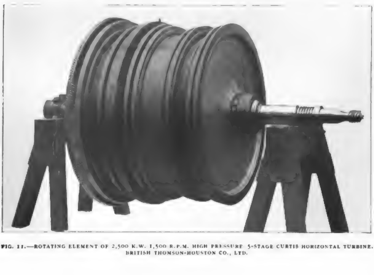


FIG. 11.—ROTATING ELEMENT OF 2,500 K.W. 1,500 R.P.M. HIGH PRESSURE 5-STAGE CURTIS HORIZONTAL TURBINE. BRITISH THOMSON-HOUSTON CO., LTD.

blade rims are put together in segments outside of the turbine, which segments are screwed on to inner ribs in the casing of the turbine. Fig. 11 shows the rotating element of a 2,500 k.w. 1,500 r.p.m. Curtis turbine. The diaphragms, which are made of cast iron, support the nozzle segments, which are likewise made of cast iron and which have nickel steel partitions cast into them. The packing toward the shaft is secured by means of a brass ring, composed of three parts,

is allowed to flow into the second stage by separate nozzles without mixing itself with the exhaust steam coming from below. It is only in the third stage that two kinds of steam work together.

The governor employed in a mixed pressure turbine has to solve the question of making the quantities of exhaust steam and live steam supplied to the turbines dependent on the exhaust steam on hand, and that in a manner different from that of the

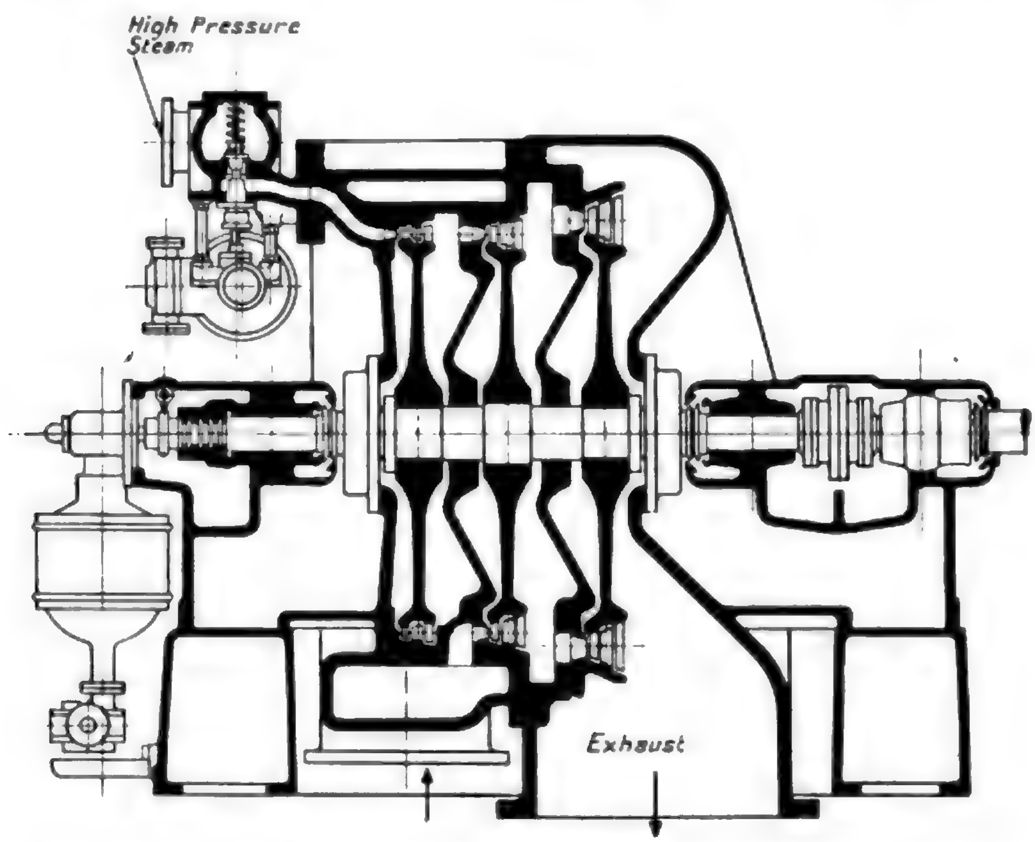



FIG. 12.—THREE STAGE MIXED PRESSURE TURBINE OF BRITISH THOMSON-HOUSTON CO., LTD.

having grooves within and which is compressed by two springs seated without. The rings are capable of expanding freely in a radial sense and are secured against any axial displacement by means of two plates screwed on at the side. They allow of but a small clearance with respect to the shaft, though there is no danger of any damage.

A three stage mixed pressure turbine is shown in Fig. 12. When live steam is supplied to the turbine it is expanded in the first stage to about the degree of exhaust steam, while it

governor of the French Thomson-Houston Company. The inlet valves of the high pressure part are governed in the same manner as in the case of the normal condensing turbine, and both the high pressure valve and the valve for the exhaust steam are under the control of the governor. Beyond that, a cam sleeve is fitted on the cam shaft of the high pressure valve the motion of which is transmitted by a lever and a link on to the valve of the exhaust steam. The link consists of a metal casing which contains a spring and a pawl and is

under control of a safety governor. The safety governor is the same as that in the case of the normal condensing turbine and shuts off by means of gear rods both the inlet valve of the high pressure part as also the valve of the exhaust steam when the normal number of revolutions is exceeded. It essentially consists of a steel ring which is heavier on the one side than on the other, and which is maintained by a spring and a bolt concentrically on the turbine shaft. In the event of a certain number of revolutions being exceeded, which may be adjusted by means of spring pressure, the centrifugal force of the unbalanced ring overcomes the force of the spring working against it, and the ring oscillates like an eccentric. At the same time it strikes against a pawl, which releases the gear rods for the high pressure valve and the pawl for the low pressure valve, whereupon both valves are at once shut by means of the spring pressed down on them.

In the case of the reducing turbines of the British Thomson-Houston Co. the steam pressure is maintained constant by a spring loaded governing piston, which is connected with a large horizontal floating lever to a servomotor, the high pressure and the low pressure valves are joined. The oil relay piston works in a similar manner as in the case of the high pressure turbine. If for example the steam pressure rises then the governing piston is pressed upwards, its spring is compressed, and the spring pressure is transmitted on to the floating lever which shuts off the live steam somewhat and at the same time opens the low pressure valve, whereby the pressure of the steam is caused to drop again.

For outputs up to 250 H.P. the British Thomson-Houston Company constructs small turbines having one to three Curtis wheels, which generally work non-condensing. All turbines are provided with a safety governor, which, in the event of the normal number of revolutions being exceeded, shuts off the supply of steam.

# THE MOTOR EXHIBITION AT OLYMPIA

## A BRIEF REVIEW OF GENERAL TENDENCIES IN CHASSIS DESIGN

**By A Correspondent**

ALTHOUGH it will hardly be suggested, we think, that we are approaching finality in chassis design, it seems to be the general opinion that this year's exhibition at Olympia would be best described—speaking, of course, broadly—by the words "Nothing new." This, however, must not be taken too literally, for although many of the firms represented had no hesitation in saying, in so many words, that they had made no change whatever on last year's models, there were many others who claimed to have made improvements in details, and there were, besides, a fair number of entirely new models.

It is not possible, within the scope of a short article, to describe or even enumerate such detail improvements; they are too many in number, and besides, such descriptions would be liable to give too narrow a view by creating impressions from the individual cases described.

It is proposed, therefore, to take only a wide general survey of tendencies dealing with the various parts of the chassis in succession. Before doing so it may not be out of place to record the fact that to a greater extent than ever before the main interest of the Show is transferring itself from the chassis to the body work. Although there were no radical departures in body design, the general standard of excellence, in refinement of outline and detail and fine finish, showed a most marked and highly satisfactory advance on anything that has gone before, and the writer does not hesitate to say, from a close personal inspection of the Olympia, Paris and Brussels Shows of the past two years, that no better display of motor carriage work has ever been brought together.

### ENGINES.

Engine design has now settled down to a fairly uniform type. Chiefly notable is the fact that every one, almost without exception, has four cylinders. The single cylinder had practically disappeared last year, and now the two cylinder type has gone also. Another feature to be noted is the advance in casting the cylinders *en bloc*. This obtains throughout in the smaller powers, but the same principle is being extended more and more to the larger sizes.

There are still, of course, many makers who adhere to the system of casting in pairs, while Mr. Austin stands practically alone in casting his cylinders singly, but it may be said that the four block has "made good," and that it makes for a neatness and cleanness of appearance which is particularly attractive. In this connection it may be mentioned that designers are going further than merely casting the four cylinders in one; they now incorporate in the casting passages for the induction, and in some cases also for the exhaust, thus eliminating the outside pipes which used to be a feature of all engines and, in many cases, a particularly clumsy and ugly one.

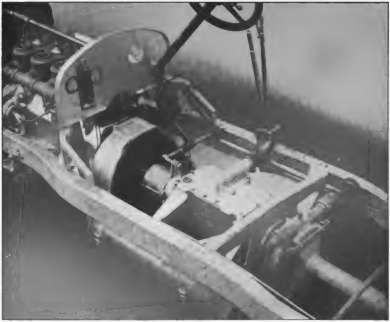
In regard to cooling, it must surely be due to the "natural cussedness" inherent in human nature that definite choice has not, long ago, been made between thermo-syphon or pump circulation. Judging from the fairly even balance in the proportions in which the two systems are used it can only be inferred that there is a very

distinct cleavage of opinion as to which is best, for while on the one hand we see that the Renault firm have never wavered in their adherence to the thermo-syphon system, still, there are other firms of hardly less repute who adhere just as tenaciously to the pump.

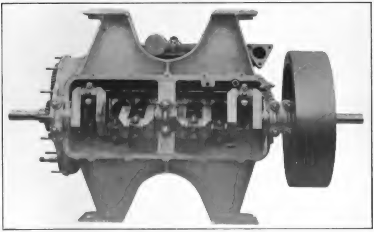
Before passing on to the next item, clutches, mention may be made of valves and valve arrangements. With but few exceptions poppet valves hold the field. The Silent Knight double sleeve valve engine has not lost any of its popularity, and the Argyll single sleeve type holds its position well and finds further additions to the list of foreign firms who manufacture it under licence; also, the Maudslay Co. have come out this year with a new type of non-poppet valve engine, but all the others seem to have died out. The Darracq Co., after two years' experience, have discarded their "valveless" engine and reverted to the old-fashioned poppets, and really, if the latter and their operating mechanism are properly designed, they are very hard to beat. With rare exceptions, valves are always arranged all on the near side of the engine, the stems and springs being enclosed by easily removable cover plates.

### Clutches.

The leather faced cone has beaten the multiple disc variety from the field by its simplicity, cheapness, ease of maintenance, and general reliability and efficiency. The single metal disc type, however, has been steered through the initial difficulties which beset it, and is now coming rapidly to the front. The chief trouble with it was in the matter of lubrication, for if the oil was thick enough to lubricate properly it prevented that



PART OF THE CHASSIS OF THE NEW 30 H.P. AUSTIN, SHOWING ENGINE, ARRANGEMENT OF CHANGE LEVERS AND GATE, AND FLEXIBLE CONNECTION TO FOOT BRAKE. NOTE THE CYLINDERS CAST SINGLY.



THE HILLMAN 15·25 SIX CYLINDER ENGINE, SHOWING SUSPENSION OF CRANK SHAFT.

rapid disengagement which is essential for noiseless, rapid gear changing, whilst if it were thin enough for this latter purpose, it failed to lubricate and was kept by centrifugal action too much off the plate.

The solution of the difficulty has been found in adopting a construction which requires no lubrication at all, *i.e.*, the light steel or bronze disc forming the driven member, instead of being gripped between metal faces, is now placed between faces of "Ferodo," or "Raybestos," both of which had previously been used for lining brake shoes and found to wear excellently. The same materials are also used now for cone clutches in place of leather, and are found to wear better and last longer.

For the transmission between clutch and gear box the general practice now is to use a shaft with universal joint couplings at both ends in order to provide against the effects of frame distortion. Instead of trun'on and pin jointed universals, the use of leather or thin spring steel discs is more frequently noticed.

GEAR BOXES.

There is not much that is new to report in gear box design beyond the fact that four speeds are steadily displacing three, and that the carrying of the change lever and gate upon a tubular projection from the box itself or its cover, and keeping it entirely detached from the chassis frame, is finding favour with many of the best makers. The idea of this is, of course, to relieve the change-lever shaft from being strained owing to whip in the chassis frame, which, on occasions, has been known to interfere with gear changing at critical moments.

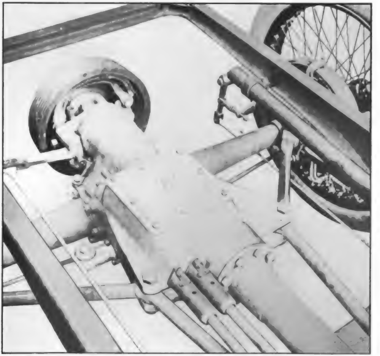
But the much more satisfactory method of placing the levers centrally in the car, and therefore directly on to the gear box, as is done in many American as well as Continental models, has not so far found any favour amongst British chassis makers.

THE "UNIT" POWER SYSTEM.

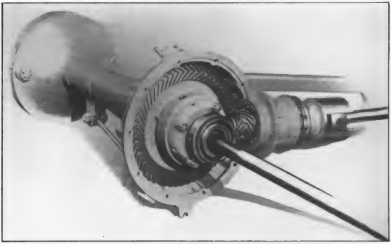
Originated by the French "Motobloc" Co., in quite early days of the motor movement, this system of building up the engine and gear box in one unit has held its own, and even appears to gain fresh adherents. And yet it may be seriously doubted whether it is right, having regard to the fact that it is now accepted in some quarters

that a moderate amount of whip in a frame is less objectionable than a too rigid one. In at least one case the gear box has been moved further back in order to permit of a longer shaft from clutch, and so improve the flexibility. The unit system must undoubtedly make for increased rigidity in the forward part of the car, and the greatly increased weight concentrated there can hardly be looked upon as an improvement. Nor do we think it can be greatly desirable from a manufacturing point of view, as the combination is heavier to handle and requires no fewer nor less intricate jigs. And finally, it is, if any thing, less easy to overhaul or repair.

Another gear box combination, not by any means new, but brought into prominence this year by reason of the fact that it has been adopted by the Daimler Co. for their 20 H.P. new model, and also by the Siddeley-Deasy Co. for their new 14-20 H.P. model—though the latter had previously adopted the same design in their 30 cwt. industrial chassis—is that in which it is built up in one unit with the rear axle, propeller shaft and casing. This arrangement was objected to by theorists on the ground that it was wrong to add to the "unsprung weight," but like various other theories, this has been disproved in practice. Being now accepted by Sheffield Simplex, B.S.A., Daimler, and Siddeley-Deasy, not to mention several American



THE ARRANGEMENT ADOPTED ON THE 1914 20 H.P. DAIMLERS. THE GEAR BOX IS COMBINED WITH THE BACK AXLE. THE FOOT BRAKE DRUM IS SITUATED AT END OF OVERHEAD WORM SHAFT.



BACK AXLE OF A MORS CAR, SHOWING DIFFERENTIAL. HALF THE COVER IS REMOVED AND THE CITROEN DOUBLE HELICAL GEARING, WITH WHICH ALL THESE CARS ARE FITTED, CAN BE SEEN.

firms, it is not unlikely that others will follow suit. It is a style of construction that should prove suitable for the very small cars which are being developed from the cycle car, and in competition with cheap American importations.

### Final Drive.

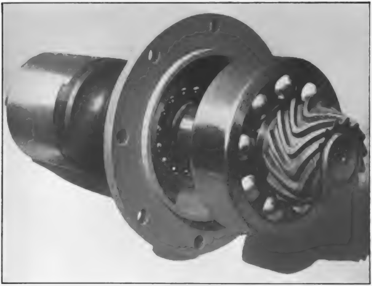
Bevel gears for back axle drive still hold premier place, in spite of the favour in which worm drive is held, and the fact that the mechanical efficiency of the worm has been demonstrated to be fully as high—except at low speeds—as the bevel. The trade is divided into two opposing camps in regard to this question, and it will be interesting to observe which side wins in the end, but we think the end is as yet far off.

The Mors Company have now adopted Citroen double helical gears for use in the back axles and differentials of all their cars. Citroen gears run with a complete absence of noise, are very much stronger than bevel gears, and give the high efficiency of 98 per cent. Comparing the Citroen gears with worm gears, they are even more silent than the latter, but of course score considerably in the way of efficiency and durability, and give no lubrication trouble whatsoever.

With regard to the steel used for the Citroen gears, experience so far tends to prove that case-hardening steel does not give quite as satisfactory results as steel undergoing heat treatment, and for the present, Citroen gears are made of the latter class of steel, such as B.N.D. and $C.N._5$. This, however, does not exclude the possibility of case-hardening steel being used eventually, although the above-mentioned steels are giving entirely satisfactory results as regards durability.

### Novelties in Transmission.

Although it is applied to only a small car, the Cowey Engineering Company showed a change speed gear which is a distinct novelty. In effect it is a variable speed clutch which provides six ordinary forward speeds, together with the usual reverse and neutral positions. The apparatus consists primarily of three parts, namely, the engine flywheel, a conical disc driven by the flywheel and attached



END OF SHAFT AND PINION AS FITTED TO THE MORS. DOUBLE HELICAL GEARING. MADE BY THE CITROEN GEAR CO., LTD., OF LONDON.

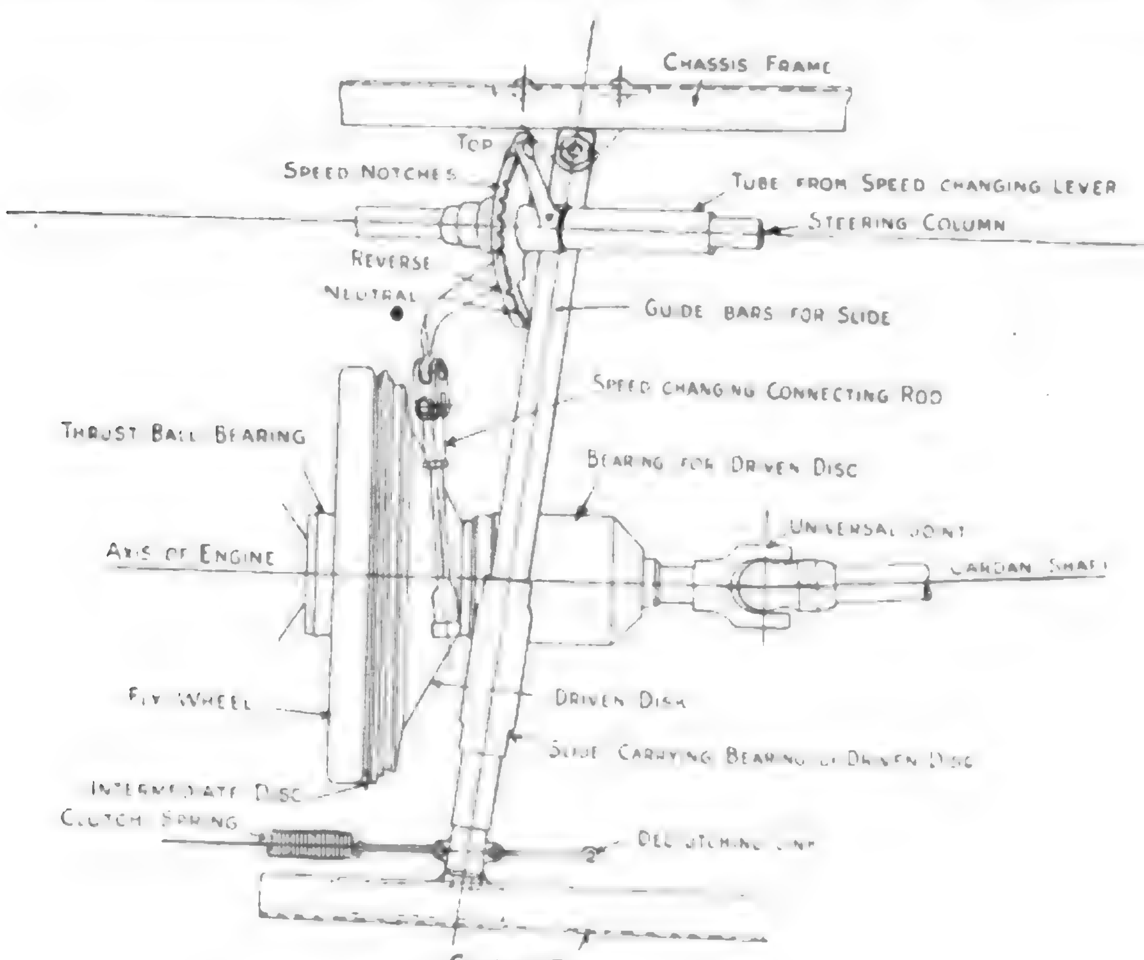
to the cardan shaft, and an intermediate clutch disc between the flywheel and the cardan shaft disc. Declutching on any gear is accomplished by merely separating the discs, which is done by clutch pedal in the usual way. The discs and flywheel are on parallel axes, and not at right angles as with friction gears, and for top gear the two axes are brought on to the same line, thus forming an ordinary clutch, the only difference being that there is no gear box. To obtain a reduction of gear the propeller shaft disc is displaced horizontally across the frame of the car, so that its axis, though still parallel with and on the same level as the flywheel and engine axis, is a little to one side of it; the rim of the driven disc now engages with a portion of the flywheel surface nearer to the centre, and consequently of smaller diameter, and thus a reduction of gear results. This method may be continued until the centre of the flywheel is approached, giving a gradually decreasing speed ratio, and by carrying the rim of the driven disc completely across the centre of the flywheel a reverse drive is obtained. Reference to the diagram will make this explanation clear.

The insertion of the intermediate disc between the flywheel and the driven disc has the effect of providing a complete annular clutch, which reduces wear to a negligible quantity. Incidentally, it may be mentioned that this little car of the Cowey Company is fitted with their patent pneumatic suspension (shown in the accompanying illustration), which does away with the ordinary semi-elliptic plate springs used in the majority of cars. In place of this they have introduced a device consisting of four piston rods connecting the car axles with pistons free to move up or down in cylinders. The upper part of each cylinder forms a large air jacket, which is part of it. The cylinder and air jacket are supplied with compressed air, which bears down upon the piston with exactly the

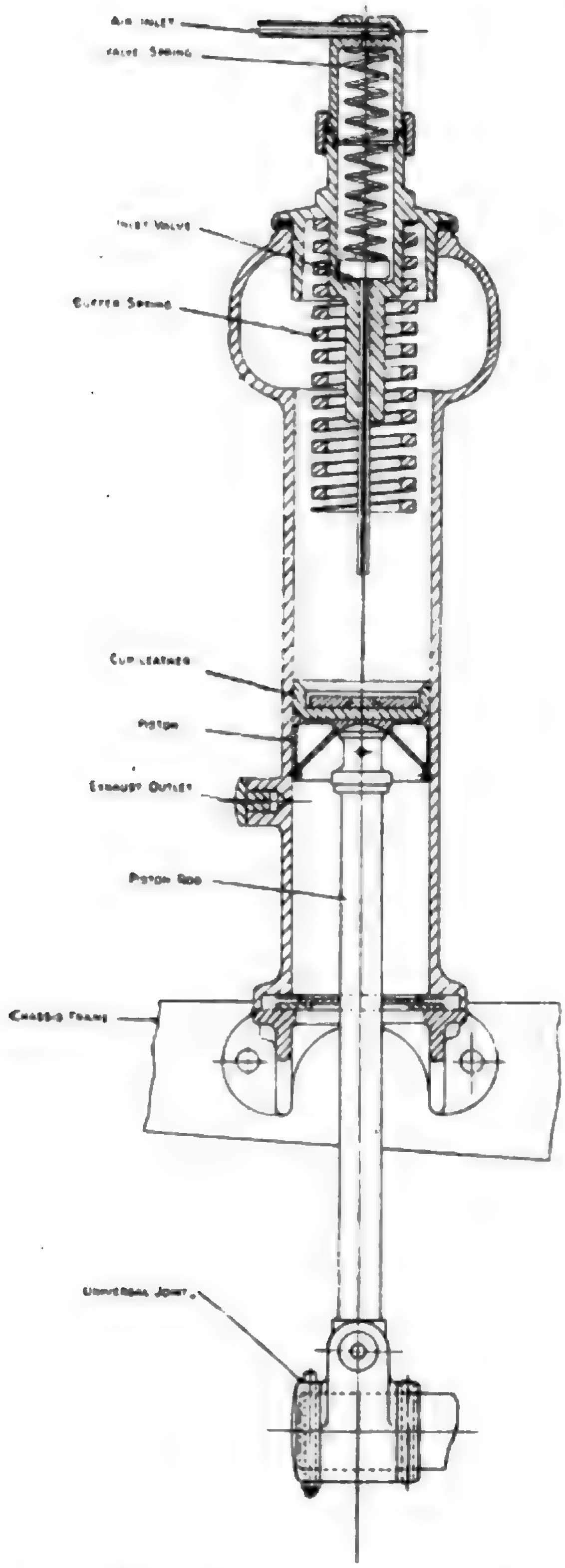
required degree of pressure necessary to maintain it in normal position, and thus supports the weight of the car; and as the apparatus is directly interposed between the two axles of the vehicle and its frame, it follows that the latter is actually floating on four cylinders of compressed air. As the car travels over the road surface the pistons reciprocate in their respective cylinders, and thus permit the road wheels to rise and fall freely while negotiating inequalities, and quite irrespective of any give in the pneumatic tyres. The combined capacity of each cylinder and air jacket is so large in relation to the piston area that the upward or downward movement of the piston can take place without making any considerable difference to the air pressure in the apparatus, and consequently, the supporting force, due to the intervention of the compressed air between piston and cylinder, remains practically unaltered. Provision is made in the apparatus to meet the difficulty of varying loads, this being accomplished by means of an inlet valve at the top of each cylinder in communication with an air reservoir, the contents of which are maintained at a sufficient pressure to cope with the heavier load which may come upon the vehicle. When the load is increased the pistons immediately rise in their cylinders, and in doing so, force open the inlet valves, and thus allow air from the reservoir to enter the cylinders until the pistons are again forced down to their normal position; in a similar but reversed way a certain proportion of air is allowed to escape should the load be decreased.

## Frames and Springs.

There is not much requiring comment under this heading. The frames especially being of the conventional pressed steel variety, which are practically standardised by all makers. In regard to springs, it is noticed that in some cases they are attached to the under side of the rear axle, instead of




Showing arrangements of the Cowey new variable speed clutch.



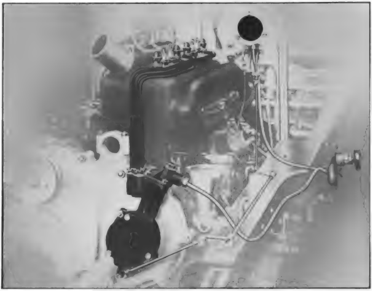
THE COWEY PNEUMATIC SUSPENSION CYLINDER.

being placed on the top. There is a tendency, too, to make springs rather wider, with less camber, and rather fewer plates. It was noticed also that the use of inverted semi-elliptic, or, as they are called, cantilever springs, is decidedly on the increase, prominent examples of this system being seen on the Rolls Royce, Sheffield Simplex, Daimler and Siddeley Deasy models.

MECHANICAL ENGINE STARTERS.

Certainly one of the features of the 1913 Exhibition is in the extent to which mechanical engine starters have been adopted. The greater proportion of these are of the electr.c motor type, these being fitted by the Siddeley Deasy, Arrol Johnston, Austin, Dennis, Sheffield Simplex, Lanchester, Armstrong Whitworth, Crossley and other firms, whilst the Wolseley and Sunbeam companies have adopted compressed air systems.

In the electric motor type there are at least two different arrangements of the apparatus on view. One, in which the same machine is used as a combined motor generator for engine starting and car lighting, the second in which separate machines are used, that is, a motor for starting the engine and a separate dynamo to provide current for the motor, and also for the electric lighting of the car. Opinions seem to be divided as to which is the better system. On the one hand, simplicity seems to favour the combined motor generator, but the use of this involves a drive from the flywheel by gear and pinion, which is not quite so smooth and satisfactory as a belt drive. Nearly all the electrical starters act upon the flywheel through a pinion on the motor spindle, or on an intermediate reduced speed shaft, engaging with a ring of teeth fitted to the flywheel. When it is desired to start the engine, the pinion is made to slide into engagement with this ring, but as soon as the main engine takes up its drive, the pinion is automatically drawn out of gear by a spring. The neatest arrangement of the combined system was seen on the Sheffield Simplex chassis, in which it is built on the engine shaft, and takes the place of the flywheel. In the Austin arrangement, instead of having a ring of teeth on the flywheel, a V-groove is used, with a corresponding friction pulley on the end of a flexible extension of the motor spindle. By means of a foot pedal, the friction pulley is pressed into engagement with the groove in the flywheel,



THE NEW COMPRESSED AIR STARTING ARRANGEMENT ON THE WOLSELEY. THE DISTRIBUTOR CAN BE SEEN IN FRONT AND ON THE RIGHT HAND SIDE THE MAIN VALVE TAP.

and although friction drives of this nature are not approved of for continuous use, it would seem that in this application the system is justified. The great expense of these electrical motor starters, and the fact that they impose a very heavy load upon the battery when starting the engine, is likely, we think, to make the market in them rather a restricted one, and we gathered that there is a general feeling throughout the trade that much more experience in their use will be required before they can be recommended for wide adoption.

The compressed air systems adopted by the Wolseley Co. and the Sunbeam Co. differ a good deal in their details. That of the Wolseley Co. (shown in the illustration) comprises a small double cylinder air compressor fitted on the gear box, and operated by a silent chain drive, and adapted to be thrown out of gear when not required. This compressor supplies air at a pressure up to about 300 lb. per sq. in., but experience has shown that from 200—250 lb. is sufficient, the higher pressure being necessary only when starting from cold in winter time. From the steel reservoir a pipe is led to a distributor valve fitted at the front end of the engine, and operated by an extension of the cam shaft. From this distributor valve, pipes are led to each of the main cylinders, and thus by operating a small lever on the dashboard, air is at once admitted to the cylinder which is in a proper position to receive a charge. The apparatus is quite simple, and it may be mentioned incidentally that the compressed air may be used also for tyre inflation.

In the Sunbeam arrangement, instead of using the compressed air in the main-cylinders, it is taken to a small three-cylinder single stroke engine fitted at the side of the main engine, the drive from this is applied to a ring of teeth on the flywheel, through the medium of a short square-ended shaft with a sliding pinion.

### Brakes.

Considerations of safety for passengers led to very careful brake designing in the earlier days of motor construction, so that any alterations or improvements now are of a minor kind, and generally take the form of refinement in details and means of adjustment.

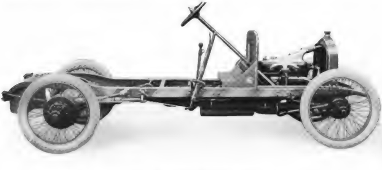
In the new models of the Daimler Co. and the Siddeley Deasy Co., in which the gear boxes are incorporated with the rear axle and propeller shaft casing, the front brake has been fitted to a rearward extension of the worm shaft, just above the back axle, a position in which it is very accessible for cleaning or adjustment. In some cases the usual gearbox brake has been eliminated in favour of an extra pair of shoes arranged side by side with the hand-operated brakes in the rear wheel hubs. Ferodo, or Raybestos, are now largely used for facing the brake shoes, in place of metal, being found to act more smoothly and to have wonderfully good wearing qualities.

### New Models.

Quite a number of firms exhibited entirely new models, and although in most cases the new designs followed closely the existing standards of the various firms in question, in one or two instances, such as the Daimler, Siddeley Deasy, and Austin, quite radical departures were noticed.

Perhaps the most conspicuous of these was the Daimler new 20 H.P. model. It has a Silent Knight engine, of course, the 4 cylinders having a bore and stroke of 90 and 130 mm. respectively.

The most important change is in the transmission, for, as already mentioned, the gear box, instead of being an independent item, between the clutch and propeller shaft is, in this case, built up as part of the central portion of the rear axle casing. The axle, as in other Daimler models, is worm driven, but the worm is placed above instead of below the wheel, in order to keep the axis of the propeller shaft horizontal, and avoid the necessity of arranging the engine and transmission on the slope.

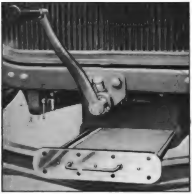


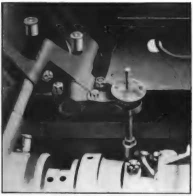
THE 15-20 STRAKER SQUIRE CHASSIS.

Attached by a flange joint to the forward end of the gear-box is the propeller shaft casing tube of steel, which terminates, at its forward end, in a ball-shaped piece that rests in a cup-shaped piece or socket fixed to a deeply-flanged cross-member of the chassis frame immediately behind the clutch.

On this cross-member are arranged, also, the clutch and brake pedals, and a clutch stop brake. The propeller shaft casing tube acts as a thrust and torque member, and is strongly connected, through lugs on the gear box, to the back axle ends by diagonal stays.

The foot brake has been already referred to as being fitted to an extension of the worm shaft, whilst the side





TWO NOVELTIES ON THE VAUXHALL. ON THE LEFT A WIDE OIL FILTER FOR CRANK CASE. ON THE RIGHT THE NEW FOOT BRAKE ADJUSTMENT.

brakes, following Daimler standard practice, are of the external band variety, acting on the outside of the rear wheel drums.

The suspension of the new model is another feature which departs entirely from the usual Daimler style, the springs being of the semi-eliptic inverted, or cantilever type. One end of each spring is attached to the back axle, while the centre, and the other end, are attached to the frame. The greater part of the weight of the spring is by this means removed from the axle, and becomes part of the sprung weight of the car. Another unusual feature in connection with these springs is in the fact that the front ends are attached immediately under the side members of the chassis frame from which points they are splayed outwards to the axle ends, the centres being shackled to projecting brackets.

The frame is of pressed steel, with parallel sides, strongly braced together by the massive cross-member behind the flywheel, and by another downwardly arched cross member situated further back near the rear axle.

The appearance of this new Daimler model gives one the impression that it should be very "lively" on the road, and its future career will be watched with interest.

# CAB SIGNALS AND TRAIN STOPS

THEIR SPECIAL BEARING ON RECENT ACCIDENTS

PART II.

**Wm. H. Dammond, C.E., F.P.W.I.**

ON British railways during the past three years there have been sixteen fatal collisions, every one of which unquestionably could have been prevented by proper signalling equipment. The cab feature of such equipment would have prevented nine of these wrecks, and the automatic feature the remaining seven. These sixteen accidents, which were due to faulty signalling systems, comprise more than three-fourths of all the fatal British wrecks during this period. A daily paper stated less than half the truth when it asserted that at Aisgill "the signals were properly set"; it failed to mention the equally pertinent facts that the signals were imp operly placed, and that a block system in which the signals appeal to the eye, and not also to the ear, is a system which does only half of its proper work.

Steam railways in the United Kingdom have made a costly mistake in continuing to use such anachronisms as mechanical signals and the lock-and-block. That this mistake is also dangerous will be evident when one reflects that collisions like Waterloo Junction, St. James', Colchester, and Farringdon Street, although quite frequent on British railways, no longer occur on a numerous class of American rail-roads which operate under British conditions, but which have been automatically signalled for several years. In both of these countries and in Germany, France, and Canada, events of the past two years show a strong tendency towards a mistake in cab systems which would be relatively both as wasteful of money and as dangerous as the British mistake regarding the different, yet closely related, subject of automatic signalling.

It is hardly an exaggeration to state that, until now, cab signal and train-stop history has been made exclusively in these five countries. It is to be regretted that in them are to be found a few railways wasting time and money on cab systems that obviously violate certain principles upon which safe signalling is well known to depend. In the meantime, cab systems that are practical and economical are being utterly neglected by these same railways. Of these five countries, France is, on the whole, perhaps least open to adverse criticism; while Germany and England are about the worst. It is no longer open to question whether, but rather how railways should be cab signalled. It is unfortunately true that an even more important question is, how shall they not be cab signalled? The answers to these two questions and the comparisons drawn in the previous article between typical systems shown therein will, it is hoped, make more or less clear the validity of certain definite requirements which are given in condensed form at the conclusion of the present article. Such a list of requirements as is here suggested is one to which all railway companies should strictly adhere in considering any cab signal or train-stop; for no inventors' wishes and no railway officials' rules can hold in abeyance the physical laws upon which safe and quick handling of railway traffic depends. Apparently, neither the contact bar systems nor those requiring small lengths of track rail to be insulated are likely to receive much attention in the future. Since, then, the danger at present seems to be

confined to the trip-cock, the "wireless," and the fixed ramp types, it is necessary to examine these three a little more closely.

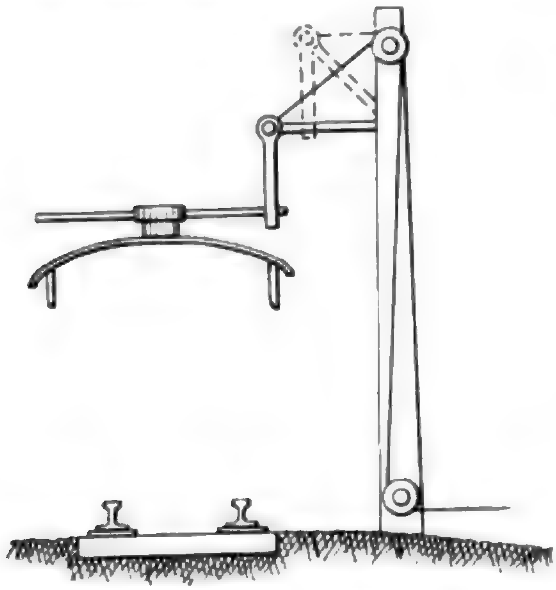


FIG. 1.—TRIP-COCK SYSTEM OF THE SUSPENDED STOP ARM TYPE.

During the winter of 1909-10, the Erie railroad tried, on its New Jersey lines, an audible cab signal and train-stop of a class illustrated by Fig. 1. This is a trip-cock system in which the stop-arm is suspended from a mast beside the track. Under gravity, this arm assumes the position shown full lined; that is, above, and relatively close to the top of the locomotive cab, this being the position of the arm when track ahead is dangerous. When the track ahead is clear, the arm is pulled upwards and to one side (mechanically or otherwise) so as to assume the position shown broken lined in Fig. 1. A trip-cock on the top of the locomotive cab is normally closed. When the train passes a lowered stop-arm, the trip-cock is opened by engagement of the trip-cock lever with the suspended stop-arm, thus causing the brakes to be applied and an air whistle to give an audible signal in the locomotive cab. The stop-arm, when elevated, permits the train to pass without incident. It should here be noted that in this suspended-arm class of systems, the trip-cock stem assumes the form of a pair of long levers extending on either side of the valve, in order to insure engagement with the stop-arm under all practical conditions.

On four-track routes and at junctions on either two, three, or four-track routes, it would be far more difficult to find room for safely locating such suspended stop-arms than to do so for the trip-cocks now in use in England and the United States. These latter trip-cocks, being on the sleepers (ties), cannot be disturbed by violent storms or winds; but the same cannot be said of a stop-arm suspended high over the track from a mast alongside. As is plainly evident from Fig. 1, this system is fatally objectionable; since the normal action of the system strongly tends, at high train speeds, to bend or break the stop-arm and trip-cock lever, and such bending or breaking would result in a dangerous error. This suspended-arm arrangement does not eliminate the possibility of sticking at clear, which was in all probability the cause of the collision at Caledonian Road, London.

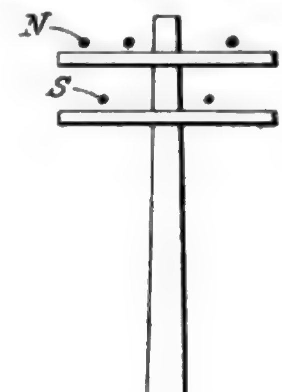
The system shown in Fig. 1 makes no provision for differentiating between a distant and a home signal at danger. We need go no further back than Yeovil to be reminded that even when a driver (engineman) *actually receives* an adverse *distant* signal he may miss a corresponding fixed home signal or (British practice) starter. This wreck, together with those at Paoli, near Philadelphia, a few years ago, at Bromford Bridge a few months ago, and at Melun, France, a few weeks ago, emphasises the need for giving both caution and stop signals in the cab. Obviously, chaos would result if the distant and the home cab siguals were not clearly differentiated. A trip-cock system of the suspended-arm class is being proposed in England. In this system, when a train passes a signal at danger an indication of that fact is given in the signal box. Why this should be done is not apparent. At both Aisgill and Yeovil, the signalmen *knew* that the trains were about to pass danger signals; but that fact did not prevent a wreck in either case.

The need for cab systems has given rise to many visionary schemes; but the long list includes very few that

are more fatuous than a "wireless" system, of either the Faradic induction or the Hertzian wave class. It is remarkable that at this late day such flagrant mis-applications of valuable engineering principles should receive serious consideration from one German State railway administration, two English railways, and one Canadian railway. Even the inferior ramp systems to be found in use in England are to be preferred to the "wireless" systems. All "wireless" cab systems either employ current to indicate danger or require that each train while running, shall be in constant communication with a wire (wave wire or primary circuit) off the train. We need not at this point dwell on systems in which dangerous errors can be produced by breaking wires or connections; but we must carefully notice certain qualities inherent in "wireless" systems which are free from this fault.

The trouble with fixed ramp systems *was* occasioned by ramp impact; but ramp systems completely eliminating this trouble have existed for at least five years. The trouble with "wireless" systems *is* interference; and this trouble remains unmitigated to-day. The expedients for overcoming *external* interference, however, valuable they may be in other applications of "wireless" transmission, are utterly worthless as applied to "wireless" train-control or cab signalling. Even if external interferences were completely overcome, wireless cab systems would still be worthless on account of *internal* interference. This trouble will perhaps be made clear by reference to Fig. 2 which shows, in cross-section, a double track route equipped with a wireless system of a type recently tried.

In Fig. 2 are wires paralleling the tracks and emitting waves for communicating with running trains. It has been suggested that the ordinary telegraph or telephone wires along the permanent way may be utilised for this purpose. Here it is assumed that trains on track N approach, while those on track S recede from the observer; this being the "left-hand" (British) running. First assume the block ahead on each track to be clear; then wires N and S will both be emitting waves. A train on either track will receive a clear cab signal, and its brakes will be held off as it passes the point here



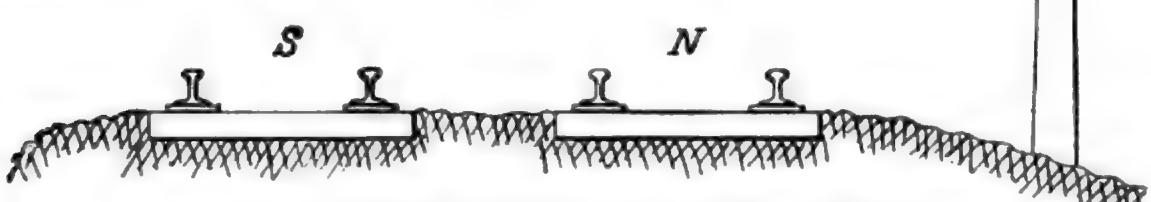




FIG. 2.—SUSPENDED WAVE WIRES FOR "WIRELESS" CAB SYSTEMS.

shown. Next suppose the block ahead on track N to be obstructed; then the signal-man (or, in automatic working, the relay) will cause wire N to be "dead." The cab signals will then go to danger (and the brakes be applied) by gravity on any train that may come on track N. In the meantime, traffic on track S must not be held up; hence, wire S must continue sending out waves. But waves from wire S must be such as will not affect the apparatus on train N, since by affecting the latter they would produce a dangerous error (false clear signal, etc.). It will thus be seen that train apparatus and line wire N must be tuned to a wave length differing from that of train apparatus and line wire S. Means for changing from one wave length to the other must be provided on each locomotive, since *every* locomotive must be equipped for running on *either* track.

A junction from the main line (Fig. 2) requires two more wave lengths, four in all, thus requiring four tuning adjustments on every locomotive. We may well pause to ask how much further complication must we introduce on each locomotive before we reach a point where such a cab system can be *really* used on an *actual* railway? Still excluding systems in which open circuits can produce dangerous errors, a wireless cab system, even for a signal wave length, is *much more complicated* than any one of the better fixed ramp systems.

cut, forming a forward and a rear portion. The cut ends, together with one end of the local loop, are run to the fixed signal. The other end of the local loop is connected to the forward portion of this severed line wire, as shown.

In Fig. 4, the fixed distant signal, in addition to its ordinary duties, serves as a diverting switch to which the rear portion of the severed line wire is permanently attached. The fixed signal, when at clear, makes contact directly with the forward line wire. When at danger, the signal is

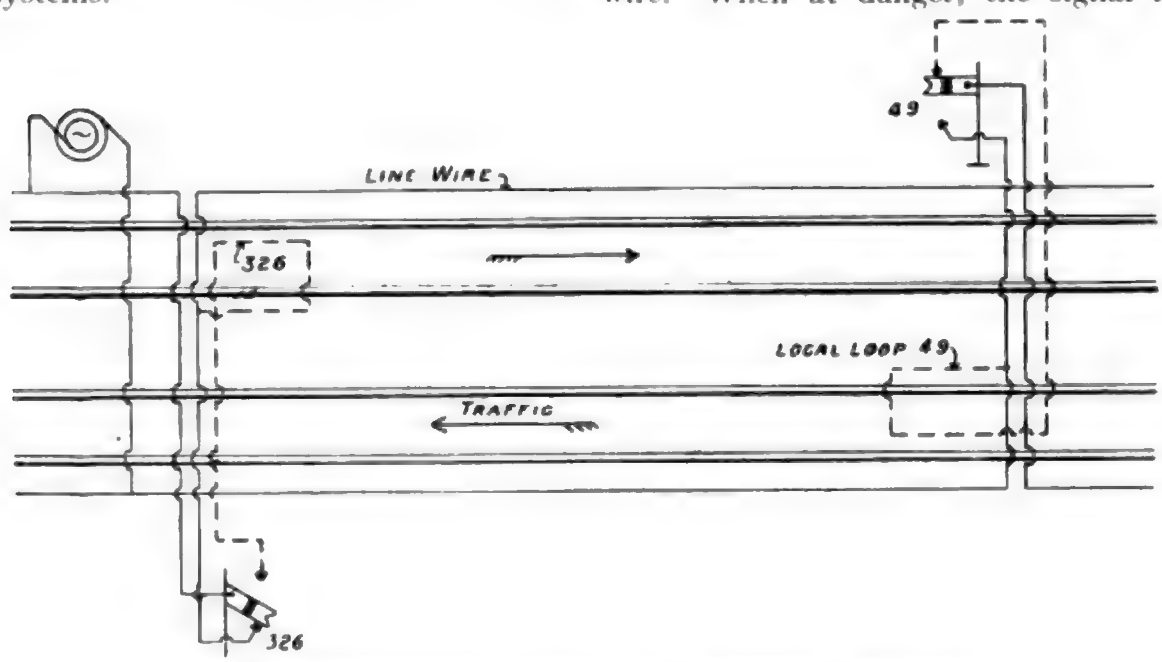



FIG. 3.—TRACK ARRANGEMENTS FOR INDUCTION "WIRELESS" CAB SIGNALS.

Fig. 3 illustrates a double track arrangement for one of the proposed cab systems of the Faradic class, this being the class to which the "wireless" system now on trial on the Midland Railway belongs. In this figure both of the fixed signals are distant; since systems of this class cannot give distinctive home and distant indications. Each track is paralleled throughout the entire route by a "line" wire, here shown full lined. A "local" wire, formed into a loop is placed on the track in the vicinity of each distant fixed signal. The local wire is laid, not on the track that it affects, but on the *opposite* track, as is indicated by the numbering of loops and fixed signals in the figure. At each distant fixed signal the line wire for the opposite track is

out of contact with the end of the forward line wire and makes contact with the end of the loop. High frequency (about 100) alternating current is fed into the *line* wires all the time. Owing to the switching action of the distant fixed signals, this current is also fed into a given local loop when the related fixed signal is at danger; but the local loop receives *no current* when the fixed signal is at *clear*.

Each train is provided with a large secondary coil wound on a frame "round the locomotive!" When a locomotive is in any given block and not near a local loop, the current in the *line* wire of that block induces an alternating current in this locomotive coil, the line wire acting at a primary, and the locomotive coil as the corres-

ponding secondary circuit. The current thus induced in the locomotive coil is what holds the cab signals at clear and the train-stop out of action. When the locomotive arrives at or near the distant fixed signal and the latter is at danger, the current in the adjacent branch of the local loop tends to induce, in the locomotive coil, an alternating current that is equal and, at any distance, opposite to the current induced by the line wire. These two tendencies (line and loop inductions) will, therefore, neutralise each other; in other words, no current will flow in the secondary coil on the locomotive. The cab signals will then go to danger (and the train-stop be applied) by gravity. When the train is at or near a distant fixed signal at *clear*, the induction from the line wire is unopposed; since the local loop at a *clear* fixed signal receives *no current*. Current will, therefore, actually flow in the secondary circuit (locomotive coil), and this secondary current will hold the cab signals at clear and the stop out of action.

Such a mammoth coil on each locomotive as Fig. 3 pre-supposes is, to say the least, objectionable. One may safely presume that no railway company would seriously contemplate putting such coils around a large number of its locomotive tenders or, worse still, around a large number of tank engines. Fig. 3 is a somewhat simplified drawing of a track arrangement for the "wireless" system being tried on the Midland Railway. It is important to note that this system is open to a dangerous objection; *it employs current to indicate danger.* This system cannot prevent wrecks like Bromford Bridge, Yeovil, or Melun, which means that in all probability it cannot prevent those like Aisgill. Moreover, as railways are actually built, this system cannot be used at all on three or more tracks.

In considering cab systems, a distinction should be drawn between "reliability" and "safety": the former term denoting freedom from *safe* errors, while the latter denotes freedom from *dangerous* errors. If one cab system produces ten safe errors per million operations, while a second system produces twenty such errors per million operations, then, all else equal, the former is twice as reliable as the latter. A cab system may be perfectly safe, but at the same time very unreliable. Simplicity is certainly a desideratum in cab systems, not alone as affecting cost, but on account of reliability as well. Bearing this in mind, let us consider two ramp-type cab systems now before the railways.

To accomplish certain results, one of these cab systems requires four ramps, two of them high and two low, per block, and not less than five electro-magnets per locomotive. To accomplish the same results, the second system requires only one ramp per block and three electro-magnets per locomotive, all ramps being of the same height. The first system requires, off the locomotive, five times as many electro-magnets as the latter. Despite the extreme complexity of the first system, its adoption by British railways is strongly urged by a daily newspaper.

Fig. 4 shows a track arrangement for the simplest case ordinarily met with in fixed block signalling, and with it the track arrangement for a supplementary cab system. Fixed signal connections are omitted, but cab signal connections are shown in full. If the signalling is non-automatic, the switch is controlled by the locking; and the signalman's duties are the same as if no cab signalling had been installed. If the signalling is automatic, a pair of contacts on the track relay replaces the switch here shown.

It is assumed that the block shown in Fig. 4 was clear for the train considered, while the next block ahead was obstructed. Accordingly, the train received clear signals in the preceding block, and must receive adverse signals in the block shown. The direction of running is "right-hand" (American practice), hence the fixed signals are shown below the track. The cab signals are given in rectangles above the track. The clear visual signal that was "picked up" in the preceding block remains

displayed in the cab until the distant ramp is reached. At this ramp the clear cab signal disappears, and the caution (run slow) visual signal takes the place of the former in the locomotive cab. The whistle immediately blows, to call the attention of driver and fireman to the change of visual cab indication. The whistle is then shut off by hand. When the train arrives at a home "running" ramp the stop visual indication appears in the cab, and the stop whistle blows. The locomotive stands at the home "standing" ramp so long as the track ahead remains obstructed. When track ahead becomes clear, cab and fixed signals change from a stop to clear, and the train proceeds.

port and Terra Cotta. Even if, as at Paoli, or at Marylebone, smoke or steam were to obscure the fixed home signal this cab system would prevent a wreck; for both driver and fireman, when running over the home running ramp, would instantly hear the stop whistle. The most complicated crossing in existence does not offer any insuperable difficulty to the proper placing of ramps in the cab system illustrated by Fig. 4. In this system there is no danger of a signal on one locomotive being sent falsely to clear by radiation or induction from a wire intended for another locomotive, and there is no need for any "tuning" adjustments to prevent such a dangerous error.

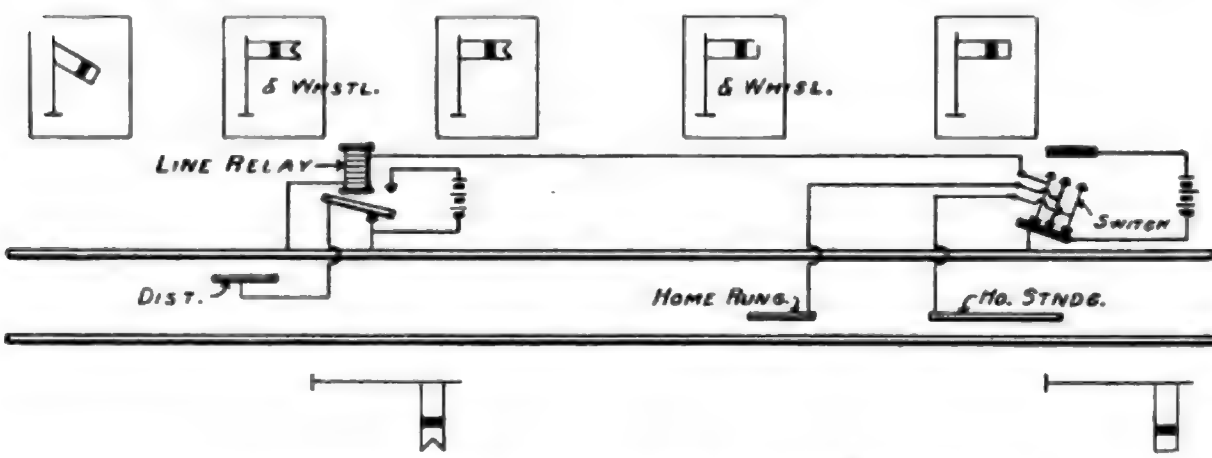



FIG. 4.—DISTANT AND HOME CAB SIGNALS SUPPLEMENTARY TO FIXED SIGNALS.

In Fig. 4 we have *continuous indications* in the cab, but do not have *continuous communication* between track and train. The former is exceedingly valuable; the latter is practically worthless, or would be if it could be attained. As yet no cab system can really give it on *actual* railways. Those wireless systems which are represented by Fig. 2, and those on trial on the London and South-Western and the Midland Railways can give such communication remote from crossings on double track roads. But such wireless systems, practically speaking, cannot even be installed at very complicated crossings.

Inferences which are plainly to be drawn from Fig. 4 show that a proper cab system gives absolute protection against wrecks like Melun and Versailles, Aisgill and Yeovil, and West-

In Fig. 4, if the system operates automatically, only two electro-magnets per block are needed on the track, only one magnet per block in non-automatic operation, these being relay magnets. On the locomotive not more than three electro-magnets are required for the case here shown. Each locomotive will require a pair of insulated wheels, which are smaller than the smallest train wheel, and which revolve only when caused to do so by engagement with ramps. By the addition of one ramp per block, and without any additional magnets, the arrangement illustrated by Fig. 4 can cause the cab signal on the above train to change either from stop to run slow, or from stop to clear, according to track conditions ahead. Without any further addition to the apparatus on the track, but by adding one electro-magnet on

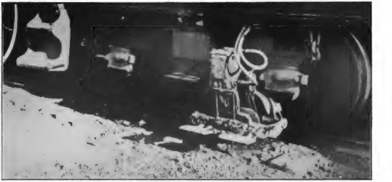


FIG. 5.—RAMP SHOE IN POSITION ON LOCOMOTIVE.

the locomotive for each additional function, this ramp type cab system can be made to indicate the train's arrival at a ramp when track ahead is clear, automatically to slow down the train at an adverse distant signal, and automatically to stop it at an adverse home signal.

The wrecks at St. James', Liverpool, and at Waterloo Junction, London, were not only alike, that is, produced by the same *real* cause; they were also attended by certain circumstances which were alike in the two cases and which, though certainly not any part of the real cause, are, nevertheless, quite important. In both cases, the real cause of the wrecks was improper signalling apparatus. Automatic signalling would have prevented both wrecks. It has been widely stated that the signalling at Waterloo Junction is automatic, but this is entirely wrong. In fact, one newspaper that made the statement that automatic signalling was in use at this junction had just told its readers that such signalling could not be used at junctions.

At Waterloo Junction the fog made it impossible for the signalman to see either the lights of some of the fixed signals in the vicinity of his cabin or a tail light on a train standing near by. How reckless, then, it is to trust to a driver's ability infallibly to get, every day, hundreds of fixed visual signals including scores of signals enveloped, many days each year, in impenetrable fog! At St. James' the case for cab signalling is, if anything, even stronger. It was testified that most of the time smoke and steam render it very difficult to see either the distant, or the home signal. At both places, then, although automatic *fixed* signals would give perfect protection against the particular kind of wrecks that really occurred, automatic *cab* signals ought to be installed. Is it enough to remove the cause of one wreck that has occurred when the cause of other and *equally frequent* wrecks is known to exist? Wrecks which can be prevented only by cab systems are frequent elsewhere, and it is definitely established that conditions strongly conducive to such wrecks were strikingly conspicuous at St. James' and at Waterloo Junction. Would it not be culpable negligence to wait until a wreck of this class actually occurs before removing the clearly perceived danger?

The United States Block Signal and Train Control Board, although a purely advisory body, with no power to enforce adoption of its recommendations, has greatly assisted the cause of increased safety in that country by publishing a list of Requirements for cab systems. If some British government commission had published such a list a few years ago, it is not very

probable that the Midland Railway would have spent over two years on one inferior cab system and followed this by spending further time, as it is now doing, on an even worse one. These two cab systems and the wireless one on trial on the London and South-Western Railway are designed in very plain violation of certain exceedingly important signalling principles. These principles are so obviously essential to the safe handling of traffic that they are not only contained in the American list of Requirements, but would, no doubt, be included in any such list which any expert board would formulate.

One very valuable advantage of publishing such requirements is that the list is sure to receive and to be improved by criticism. This has been exemplified by the Train Control Board's list, which really evolved from a set of requirements compiled by the Railway Signal Association, of America, in October, 1908. The "New Haven" Railroad adopted the Train Control Board's version with several substantial improvements, one of which effectually condemns such systems as that now being tried on the Midland Railway. A serious defect in the "New Haven's" list is the requirement that the system must be of such a character that, unexceptionally, the occurrence of a cross between two electric wires shall not be able to cause a dangerous error. The American Railway Association's Committee, of which Mr. E. C. Carter, chief engineer of the Chicago and North-Western Railroad, was Chairman, has more recently published a set of requirements which improves upon the "New Haven's" list by excluding this stipulation as to crosses.

It is impossible here to give the subject of crosses the extended consideration it deserves. Briefly, there are, on the locomotive, certain cases of crosses which are physically possible, but which cannot occur accidentally or from careless or inefficient maintenance. In these particular cases, the *purely theoretical* danger of crosses can be eliminated only by introducing complications into a simple system. If two wires are carried on opposite side-frames of a locomotive, and the cab apparatus is such as would be sent to danger by the grounding (earthing), or the breaking of either or both wires, or by any combination of grounds and breaks on either or both wires, how could accident or even extreme carelessness send the cab apparatus to clear by crossing?

At present, railway companies can easily get cab signals and train-stops which fulfil the following fourteen requirements:—

1. Three distinctive visual indications, namely, "clear," "caution" ("run slow"), and "danger" ("stop"), shall be given in each locomotive cab. A system which gives a green light for clear and a red light for danger, must also give a third light, for instance, yellow, for caution.

2. The visual cab signals shall not be given intermittently (at ramps only), but continuously, throughout the entire run of the train.

3. In addition to the visual cab signals, there must be on each train an audible signal, which shall sound when the visual cab signal changes to caution or to danger.

4. The system must be capable of opening an air, or vacuum-brake valve, at a distant or at a home signalling point, or both as may be desired, and this same requirement extends to starting signals, where such are used.

5. In addition to the cab signals (see requirement No. 1), the system must provide cab indications, both visual and audible, for notifying driver and fireman when the train arrives at a ramp.

6. Any ramp-engaging member must be of such a character as to reduce ramp impact, at train speeds of thirty miles per hour and upwards, at least forty per cent. as compared with a ramp-shoe of the same weight.

7. No exposed moving parts shall be required on the track, either on the ground or suspended from poles.

8. Neither springs nor magnetism shall be required to produce a danger result (cab signal or train-stop). The visual signals must go to danger by gravity alone; and each audible signal

and train-stop valve must open by gravity alone or by gravity assisted only by the air or the steam which the valve controls.

9. It must be impossible to cause a dangerous error (for example, display of a clear or a caution signal when the correct indication would be danger) by producing one or more earths (grounds), one or more open circuits, or any possible combinations of earths and open circuits in the systems.

10. The failure of any electric source or sources must not be able to cause a dangerous error.

11. The system must be of such a character that there shall be practically no possibility of a dangerous error as the result of a cross.

12. In case a ramp-engaging member should break, by ramp action or otherwise, in such a manner as to interfere with proper engagement with any corresponding ramp, any resulting error must be a safe error.

13. The system must not be a "wireless" one, as it must be immune to *internal* interference, must be capable of control by a.c. or d.c. track circuits, and must be applicable to conditions of the densest traffic and at the most complicated crossings.

14. The number of safe errors of the cab system must not be materially greater than the number of such errors in the best automatic fixed signals.

A requirement that is purposely excluded from this list is one to the effect that the cab system shall be proof against malicious interference. Surprising though it may be, one technical journal actually makes this requirement, although it is well known that there is not a railway signalling system in use anywhere, and never has been one, that could fulfil it. Maliciousness did not cause the wrecks at Terra Cotta, on the Baltimore and Ohio; at Paoli, on the Pennsylvania; at Westport, on the New York, New Haven and Hartford; near Versailles or at Melun, in France; nor at Aisgill, Yeovil or Bromford Bridge, in England. Cab systems would have prevented every one of them. Wrecks resulting from malicious interruption of signal operations are exceedingly rare; wrecks caused by exclusive fixed signalling are exceedingly numerous. Are we to refrain from adopting a system which will prevent wrecks that now occur simply because it will not also prevent conceivable wrecks that do not occur?

# THE NEW DOCKS AT HULL

**By a Correspondent**

THE shipping facilities of Hull will shortly be increased by the addition of a new dock. This dock, known as the New "Joint" Dock, is being built by the firm of Messrs. S. Pearson & Son, Ltd., Westminster, for the two Railway Companies who serve the port, viz., the North Eastern and the Hull and Barnsley Railways. The dock works are finished up to high water level, and water is now being allowed to accumulate in the basin The commercial community of Hull is looking forward with great interest to the opening of the dock, which, when completed, will be one of the largest and most finely equipped, and up-to-date docks in the country. The dock, which has been built on land reclaimed from the foreshore of the River Humber, has at present a water area of 53 acres. The whole of the estate on which the dock is built consists of 206 acres and has a frontage on the river of about a mile.

The dimensions of the main dock are 1,000 feet by 1,050 ft., whilst those of the north-west and the north-east arms are 1,356 ft. by 325 ft., and 1,350 ft. by 450 ft. respectively. The total length of quay measures 8,162 lineal feet. By the addition, later, of two more arms the water area will be increased to 85 acres. A rough plan of the dock is shown in Fig. 1. A most interesting feature of the dock is the entrance lock—(Fig. 2),—one of the finest yet constructed. It is 85 ft. in width, and is divided by three pairs of gates into two pens of 500 ft. and 250 ft. respectively, making a total length of 750 ft.

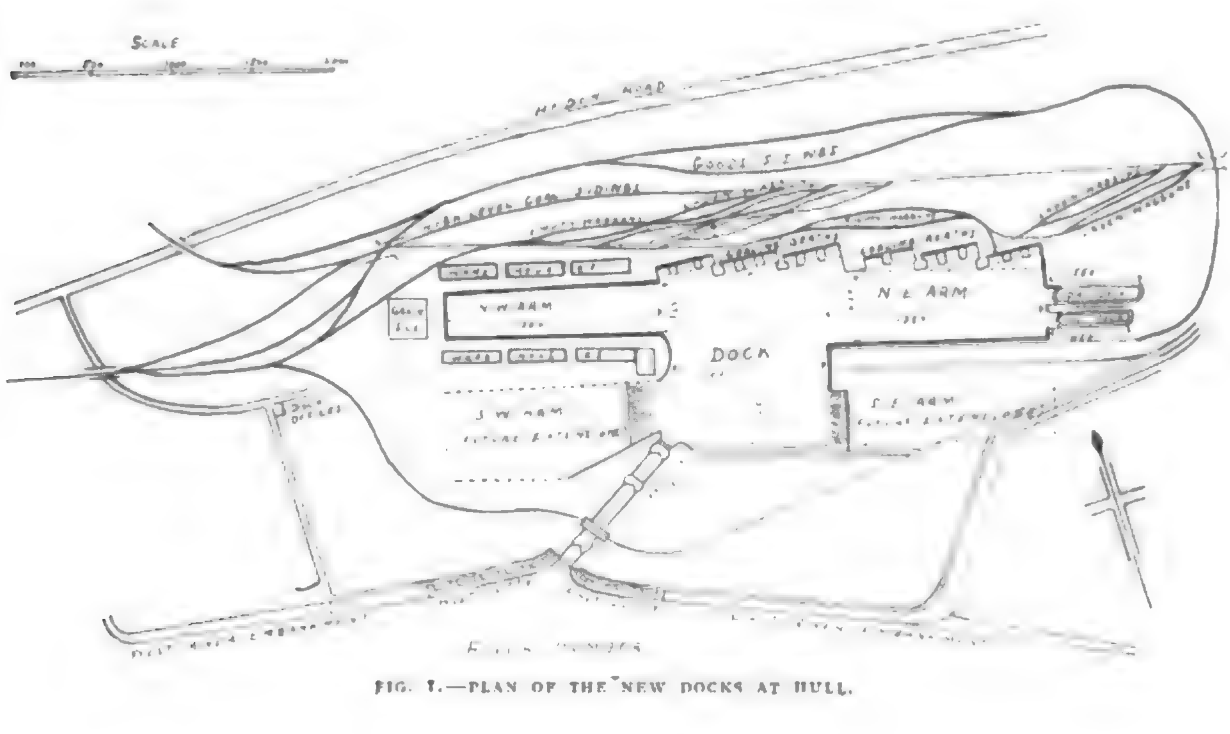



FIG. 1.—PLAN OF THE NEW DOCKS AT HULL.

FIG. 2.—THE ENTRANCE LOCK.

The walls of the lock are built of concrete faced with brickwork to within 18 ft. of cope level and above that with granite. The invert or floor is made of concrete faced with brickwork. The middle and outer sills are three feet lower than the inner sill, and sluicing or levelling culverts have been arranged at each side of the lock at each pair of gates so that water can be passed between the dock, lock, and river while the gates are closed. Vessels of large draught will thus be able to enter or leave the dock earlier than if the sills were all the same level. The depth of water in the inner sill will be 39·29 ft., and on the middle and outer sills 42·29 ft. at high water of spring tides.

The lock gates, shown in the course of construction in the accompanying photograph—(Fig. 3.)—have been built by Messrs. Sir W. C. Armstrong, Whitworth and Company, and are considered to be a very fine piece of engineering skill. The power will be produced entirely by electric motors. The gate platforms will be kept free from obstruction by means of the sluicing culverts.

Six coaling berths have been provided and these have been arranged so as to save a considerable amount of quay space (see Fig. 1). Electric coal conveyors, each capable of dealing with from 700 to 1,000 tons per hour, are to be provided, and each conveyor will have a separate set of sidings for laden and empty wagons, and each will be worked independently.

A great deal of work still remains to be done in fixing up the numerous cranes and erecting the general equipment which is to be of the most modern character. There are to be nine 10-ton and twenty-five 3-ton electric cranes on the quays, and, in addition, a floating crane, capable of lifting 80 tons, will be provided in the dock for heavy lifts.

A silo, with a storage capacity of 200,000 quarters of grain, is being erected at the west end of the dock. Commodious warehouses of two storeys, built of ferro-concrete, and having a total floor and roof area of 48,750 square yards, are now in course of

FIG. 3.—LOCK GATES IN COURSE OF CONSTRUCTION

FIG. 4.—ENTRANCE TO THE TWO GRAVING DOCKS.

FIG. 5.—SMALLER DRY DOCK, 450 FT. LONG, 66 FT. WIDE.

construction. Six electric cranes, with a lifting capacity of 1½ tons each, are to be provided on the roof platforms of the warehouses for dealing with goods from ship or rail. Provision has also been made for the erection of a large cold storage.

Two graving docks, 550 ft. and 450 ft. in length respectively, have been built, the longer one being 72 ft. wide at the entrance, and the shorter one 66 ft., and both will have a minimum depth of water on the sills of 22 ft. Figure 4 is a photograph of the entrances of the two dry docks, and shows the preparation for the erection of the gates, whilst Fig. 5 gives a full length view of the smaller dry dock. It may be mentioned that space has been reserved for a third graving dock, which, when constructed, will be 700 ft. long by 81 ft. wide at the entrance.

The two Railway Companies, in deciding on the equipment, have freely consulted the different trades concerned, and it is believed that the result will prove most beneficial to all parties. There is no doubt that the opening of this fine dock will largely expand the business of the port and city.

# FIRE PREVENTION IN SHIPBUILDING

By James C. Sellers

THE burning of the s.s. *Volturno* at sea has called special attention to the long-neglected need of adequate fire prevention in the construction of passenger carrying vessels. With the growth of the modern steamship carrying several thousand souls the need of such precautions has become more imperative. Longitudinal bulkheads have been added to the cross bulkheads to keep the vessels afloat if damaged by collision at one or more points, and vital parts have been so placed that injury from external contact is almost impossible. Little has been done, however, to reduce the danger from fire, for the state rooms and the superstructure generally, which have been constructed of wood. Out of the three recent serious fires, two have occurred while the vessels were in dock, and would have proved much more serious but for the ship's fire department, augmented by the city fire departments and the harbour fire tugs.

The construction of a fire-preventive ship is not only theoretically possible, but commercially practicable. It can be accomplished by the substitution of steel for wood in the construction of the superstructure and the furnishing of the public rooms and cabins.

To demonstrate how this can be done, a model cabin made of light sheet steel, has been erected by Roneo, Ltd., at their offices in Holborn, and furnished with steel cabin furniture (Fig. 1), such as has been largely used in the equipment of battleships. The walls of this cabin have been made of two sheets of steel, separated by air chambers, which type of construction is more suitable for fire-resisting bulkheads than solid steel plate.

It has been repeatedly demonstrated that two thin sheets of steel, say from 18 to 20 B.W.G. in thickness, with an intervening air chamber is much

FIG. 1.—CABIN MADE OF LIGHT SHEET STEEL, AND FURNISHED WITH STEEL FURNITURE BY THE ART METAL CONSTRUCTION CO. (RONEO LTD.).

more effective as a fire retardient than ½ in., or even 1 in. solid plate. The uneven expansion under high temperature of the two faces of the solid plate, forming a bulkhead, causes it to buckle and open up at the joints, whereas if the bulkhead be made as above described, the air chamber prevents the sheet on the side away from the fire becoming superheated, with the result that it remains in place and prevents the spread of fire. The weight is practically the same as if made of wood, and the cabin framing can be produced at only a slight advance over the cost of wooden framing.

Double steel cabin partitions are built with air chambers for resisting fire, and constructed so they can be easily fitted around beams, angles or channels. The modern passenger vessel with its long corridors of dry, highly varnished wood, presents a risk from fire which is receiving serious consideration from the naval architects. A fire once started, there is a great risk of its sweeping the entire superstructure of a ship before the life-boats could be launched. Steel cabin doors are used in connection with steel cabin framing, so that each room is a unit in itself, and it would be impossible for a fire to spread from one cabin to another.

As applied to new ships, these questions will no doubt have due consideration, but what about the larger number of ships already in commission? Ships now in service can be made reasonably safe by the introduction of fire-resisting bulkheads dividing the superstructure into sections. All ships are divided below the water line into watertight compartments, and at a small expense the bulkheads, which form them could be continued to the upper decks, and light hollow doors introduced at all openings. By this means, a fire could be either extinguished or held in check until it had burnt itself out.

This system was installed for the first time by the Cunard Company in refitting the s.s. *Carmania* (see Figs. 2 and 3), and has been adopted not only for the new s.s. *Aquata ia* now under construction, but for their entire fleet. The Holland Lloyd s.s. *Gelria* was

FIG. 2.—DOUBLE STEEL DOORS IN STEEL BULKHEAD, DIVIDING S.S. "CARMANIA" INTO FIREPROOF SECTIONS. RONEO, LTD.

FIG. 3.—ANOTHER STEEL DOOR ON S.S. "CARMANIA."

equipped with fire-resisting bulkheads built up of wood and asbestos board, and the question of fire protection is also being considered in connection with the s.s. *Vaterland*, now being built by Messrs. Blohm and Voss for the Hamburg-American Line. The importance of some provision of this kind cannot be too strongly urged, for the danger is great.

People of all nationality and all degrees of intelligence are passengers on the modern leviathan. The carelessness of one of them might cause fire in a state room which, once it had eaten its way into the long corridors built entirely of dry, varnished wood, would be carried by the forced draught caused by the rapid motion, the entire length of the ship in a few seconds.

It is satisfactory to note that without being compelled to do so progressive steamship companies are taking necessary steps to protect the lives of their passengers from fire, and it is to be hoped that the International Conference now sitting to consider the "Safety of Life at Sea," will make some recommendations regarding this matter.

Nowhere is steel of greater value than for the equipment of the ship's kitchen, pantry and scullery, for it is not only of value as a preventative of fire, but when finished in stoved enamels it is much more easily cleaned than other materials, and consequently more sanitary.

However well wooden fittings may be used there are always joints that open up with the changing temperatures

to which it is subjected, and these, together with any cracks which occur from the splitting or warping of the wood, offer a refuge for microbes which can find no lodgment in steel fittings.

The drawers are mounted on channel runners working on the principle of the piston of an engine, so they always work easily.

These steel drawers are also used for the fitting up of the purser's office so as to protect the current documents from fire and economise space. The passengers are provided with lock up boxes similar to those found in a safety deposit for the safeguarding of their valuables. Two keys are required to open these boxes, one being left with the purser and the other being held by the passenger.

On the s.s. *Aquatania*, in addition to the steel interior fittings, it is proposed to fit the front of the purser's office with a steel counter, above which is to be placed a steel roller shutter, so it becomes another steel unit in itself and further reduces the quantity of burnable material.

It has been suggested that the use of so called " fire proofed " wood meets the requirements, but apart from not being so effective as steel in resisting fire, the processes of treatment which have come under the writer's observation have caused the wood to shrink or so deteriorate that it has been far from satisfactory.

The manufacture of steel furniture has now been so perfected that all of the private cabins and public rooms can be fitted out in steel. Wardrobes, chests of drawers, washstands, &c., for the cabins, sideboards, buffets, dining tables are now made of steel, and when finished with stoved enamels, enriched with bronze, produce a beautiful and artistic effect.

Sharp and graceful mouldings have been drawn cold from special sheet steel, so architectural designs can be followed for the panelling and decoration of dining saloons and other public rooms.

The steel used for the furniture panels and mouldings is from 18 to 20 gauge in thickness, so the weight is no greater than if the work were produced in hard wood and in some cases it has worked out even less.

For battleships the steel furniture has already been largely used not only for a prevention of fire, but because steel does not splinter and it has been found in the past that many fatalities have been due to flying splinters.

Here is weight of greatest importance, and it was actually found in the equiping of a cruiser that although 50,000 lb. had been allowed for the wooden furniture that the steel furniture providing the same accommodation only weighed 40,000 lb.

The logical conclusion of this proposition is the entire elimination of wood in the fitting and furnishing of steamships, and the steamship company which follows this out to the fullest extent will merit and no doubt obtain its reward in increased patronage of the travelling public.

# Current Topics

### Temporary Overhead Travellers for Building Construction.

THE advantages of erecting temporary steel gantries, carrying overhead travelling cranes for the handling of materials in the process of building large offices and similar structures, are well emphasised by the application of this idea in the erection of the new Government Stationery Department premises in Waterloo Road. These buildings are of reinforced concrete on the Hennebique system throughout. All jib cranes, derricks, barrows and trucks are abolished by the use of the travellers, which are arranged to cover practically the whole area. The temporary gantries were constructed in sections, which are bolted together instead of being rivetted, so that after their removal upon the completion of the building it will be possible to adapt them for other building erection work of different size and conformation. The gantries have three parallel runways, each covered by a 1½ ton electric crane. The cranes are equipped for hoisting, lowering, traversing and travelling, so that a load can be picked up and deposited anywhere and at any height within the gantry structure. It is, of course, the "universal" property of this method of building construction which gains for it the many advantages that are at once apparent when compared with the more usual equipment of building cranes of the jib and derrick type. Although naturally more expensive to construct than the latter, it is believed that considerable savings may be effected in time and labour, and it is suggested that the principle is one which might well be employed in many similar cases.

### A Fire Damp Indicator for Mines.

IN connection with the recent mine explosions, the particulars of a German invention are interesting. The apparatus in question is called the "Fire Damp Whistle," and is intended to indicate the pressure of explosive gases in however small proportions. It consists of a specially constructed whistle, through which a current of air is continuously blown. So long as the air is pure an ordinary tone is maintained, but should there be one per cent. of dangerous gas present the tone becomes broken, the unevenness increasing in proportion to the amount of gas present until at five per cent. a series of booming notes are produced, constituting a warning to all within hearing. Tests were recently carried out in the presence of the Kaiser, who expressed his satisfaction with the results and his opinion that it would be the means of saving many lives.

### Oil on the Waters.

SIR RAY LANKESTER, in the course of an interesting article in the *Telegraph*, dealing with the historical and scientific aspects of this subject, states that the first man of education and position to draw attention to the matter in modern times was Benjamin Franklin. In 1757 he was at sea with a small fleet, and was astonished to observe the smoothing of the waves by the oily "cook's waste" which poured from one of the ships. In this way be became interested in the application of oil to safety in navigation.

In 1844 a commission was appointed by the Dutch Government to experiment on the subject, since Van Beek and others had urged that "oiling the sea" might help not only to prevent the swamping of shipping by breaking seas, but to prevent such seas from destroying the great sea walls or dykes of the Dutch Coast. This commission experimented with the "rollers" in shallow water near shore, but results were not a success, and so far as such waves are concerned their failure is explained. The oil films only acts so as to prevent the "breaking" of waves in deep water.

The next important step in the history was made by Shields, the engineer, about 1876, who experimented with oil at the bar of the harbours of Aberdeen and of Folkestone. He used pumping apparatus, and an altogether unnecessarily large quantity of oil—£20 worth in a couple of hours. In 1883 the matter was taken up by the American Board of Admiralty, and the evidence of ships' captains collected and experiments made. Forty or fifty careful statements from ships' captains are now on record, showing that great breakers, driven over the stern by a following wind, were almost immediately changed in character by pouring a pint or two of oil out behind. The oil, being lighter than water, spreads over its surface with astonishing rapidity, and to an astonishing degree of tenuity.

There is a consensus of opinion that the gradual dripping of one pint of oil per hour is enough. A ship running 10 knots, and slowly dripping out oil, will leave a perfectly smooth wake, 10 knots long by 40 ft. wide, covered with a film of oil. The thinness of this film is beyond description; it is that of the black part of a soap bubble.

### Capital and Labour.

IN the course of his presidential address to the Institute of Marine Engineers, Mr. Thomas L. Davitt dwelt upon the need for more harmony in the relations between employers and employed, which he considered of more importance in the engineering and shipbuilding trades than perhaps in any others, and emphasised the good that would result to both sides could such conditions prevail. This seems too obvious a truth to need labouring, but unfortunately the men, in too many cases, do not realise it.

We heartily ageee with Mr. Davitt in deploring the methods which the men's present leaders have adopted of setting class against class. With the principles of sound trade unionism, we do not think many employers will quarrel. On the other hand, collective bargaining is of distinct benefit, *provided it is collectively enforceable.* But, unfortunately, is is only too painfully apparent to-day that, generally speaking, the Unions are not directed by trade unionists, but by political wire-pullers, who in a very subtle manner have captured these organisations, and are now exploiting them in furtherance of purely political aims. We suppose that it will only be by painful experience that the men will realise that the very last thing many of these agitators are out for is the real welfare of those who they claim to represent.

So long as they permit agitators to guide the destinies of their unions, whose avowed purpose is to foster discontent and foment friction between employers and employed, no better relations can be cultivated. Indeed these leaders desire nothing less than better relations or more harmonious working. Their attitude is well instanced in their bitter opposition to all forms of co-partnership or profit-sharing

which, generally speaking, have admittedly resulted in better conditions for the workers, and mutual benefit to employers and employed. Such an attitude is, in itself, sufficient comment on their hypocritical claim to be fighting for the real welfare of the labouring classes. Mr. Davitt does well to draw attention to this question, for we are convinced that once labour, organised and unorganised, can be made to understand that harmonious working is going to be of direct benefit to it, and that the interests of capital and labour are not diverse but identical and interdependent, a very big step will have been taken towards the solution of many of the economic problems that are causing so much unrest just now.

### The Diesel Engine Explosion at Bray.

THE wheels in Government departments move slowly, and the Home Office report, dealing with the circumstances of the explosion at the electricity generating station at Bray, which occurred on July 10th, 1912, has only recently been issued. It will be remembered that the explosion resulted in the death of the head fitter and very serious injuries to the chief and assistant engineers.

The Diesel engine in question was of the single cylinder four-cycle type, developing about 50 h.p., and began running in March, 1910. Compressed air for fuel ignition and starting purposes was obtained from a two-stage compressor directly driven from the main shaft. An inter-cooler was provided for cooling the air between the two stages of compression, and the air passed through another cooler after the final compression. From this after cooler, the compressed air at a pressure approaching 900 lb. per square inch, passed through a ½ inch copper pipe into the blast air vessel, from which it was conveyed to the fuel valve. The air pressure in the blast vessel was regulated according to the load on the engine.

On the day of the accident the pressure in the air vessels was too low to admit of starting. Therefore, following the direction of the makers, in such cases, oxygen from a cylinder was utilised to bring the pressure up to the requisite standard. Compressed oxygen had been used for this purpose previously without any ill effects, but on this occasion an explosion followed immediately the engine started running.

After exhaustively reviewing the circumstances, Mr. G. Stevenson Taylor, the inspector, came to the conclusion that the explosion was caused by the ignition of an oily deposit in the blast vessel, and that the ignition was transmitted by a flame explosion from the fuel valve casing, passing along the blast pipe.

In a series of recommendations arising out of this accident the inspector points out the danger of using oxygen for re-charging air vessels, emphasises the necessity of only employing thoroughly competent and experienced men as attendants for Diesel engines, and recommends the fitting of a device for preventing the transmission of flame along compressed air pipes.

### A New Use for Wireless?

ALTHOUGH the experiments recently carried out by the staff of the Torpedo School on the cruiser *Terpsichore*, in Stokes Bay, were officially stated to be merely tests of new submarine mines, there are persistent rumours that in reality an invention of an Italian, Professor Ulivi, was being tested. This gentleman claims to have discovered certain electrical rays by means of which he can explode magazines and mines up to a distance of eight miles.

There is no reason for stating that such a feat would be impossible, since our knowledge of wireless applications of electricity is as yet in its infancy, and new and startling developments along these lines may be expected. At the same time, without more definite information, too much credence must not be placed on such reports. An obvious difficulty seems to be that of directing or confining such rays. Moreover, unless some receiving device was necessary to render them effective, all explosives within a given zone would be in danger. Only quite recently the

War Office was badly hoaxed by a man who claimed to have constructed an electrical apparatus which would short circuit the ignition apparatus of aeroplanes and so stop their engines.

Of course should there be any value in Professor Ulivi's invention the possibilities that are opened up are appalling to contemplate and an utter revolution in warfare would result. Moreover, the mere suggestion of such a possibility lends colour to the idea that war in time will be made impossible by the very engines of destruction intended to render it easy of accomplishment.

### Motor Headlights.

ALL road users know and suffer from the dazzling effect of powerful motor headlights. The effect of meeting a car so equipped is positively blinding, and many accidents have resulted therefrom.

It is satisfactory to know, therefore, that investigations have recently been undertaken at the National Physical Laboratory with a view of solving the problem of how to obtain a really efficient headlight and at the same time to eliminate this dangerous feature which at the present time characterises all makes on the market. The President of the Local Government Board recently visited the Laboratory to witness the result of these investigations, but so far no details are available.

### International Engineering Congress.

IT is proposed to hold an International Engineering Congress in San Francisco in September, 1915, in connection with the Panama-Pacific International Exposition in that city. The Congress, in which engineers throughout the world will be invited to participate, will be under the auspices of the following engineering societies of the United States:—American Society of Civil Engineers, American Institute of Mining Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, The Society of Naval Architects and Marine Engineers.

The Institution of Naval Architects is officially participating, and it is probable that many other British engineering societies will also be represented.

It is anticipated that all travelling arrangements will be made by the American Committee of Management, so that those taking part in the visit will, on payment of an inclusive price, have their steamship, railway and hotel accommodation reserved throughout the entire trip. Further details will in due course be issued as received from the American Committee.

### Ghent Exhibition Award to "Cassier's."

IT will interest our readers to know that CASSIER'S ENGINEERING MONTHLY has been awarded a Diploma of Grand Prix for an exhibit at the Ghent Exhibition. The exhibit consisted of current and past issues, together with special numbers, such as the "Oil Power," "Marine" and "Railway" numbers, and some specially bound copies. The only class in which this exhibit was entered was that for Technical Literature, and we feel we have every reason to be pleased with the successful result.

# BOOK NEWS

### The Diesel or Slow-Combustion Oil Engine.

By G. James Wells, Wh.Sc., and A. J. Wallis-Tayler, C.E. Crosby, Lockwood and Son. London, 1913. 7s. 6d. net.

This book is due to the collaboration of two versatile authors, and is a curious combination of a theoretical treatment of heat problems and the practical construction of Diesel engines. Both the authors are evidently thoroughly familiar with the subject, but appear to have had some doubt as to how much they should assume that the reader already knows.

The book is divided into ten chapters and two appendices, the first chapter being a brief account of the origin of the Diesel or slow-combustion type of engine, and the second, third and fourth chapters dealing with the theoretical treatment of heat. This portion of the book is exceedingly well written, and can be studied with considerable advantage by anybody, whether interested in the Diesel engine or not. On page 39, in Figs. 11, 12 and 13, some interesting diagrams are given of Pee-Vee and Theta Phi under the conditions of expansion and compression at constant volume, and alternatively of expansion or compression at change of volume but constant pressure. The chapter then goes on to describe the constant pressure cycle in more detail. Chapter five deals with the question of liquid fuels generally, and comparison is made of the relative value of coal and oil as a fuel. This starts with both fuels at a very low figure, and ends up with comparing oil at 62s. 4d. per ton with coal at 34s. The authors make some deductions from these figures [and arrive at the conclusion that oil fuel at 50s. per ton is in equality with coal at 16s. 4d. As a matter of fact, slack for gas producers can be obtained in the North of England for between 12s. and 13s. per ton, and if the by-products, such as sulphate of ammonia and tar, are recovered these may be taken to be of about the value of 2s. 6d. per ton of fuel gasified, so that with oil anywhere above 60s. per ton it becomes difficult to make out a case for the Diesel engine for stationary purposes in Great Britain; that is, of course, on the fuel consumption alone. On page 67 the authors repeat the statement that:—

> "Recent geological researches have proved that there is at least as much, and probably more, liquid fuel than coal on the globe."

This may be perfectly true, but considering that the supplies of liquid fuel are in the hands of about half a dozen powerful financial groups who are closely allied to one another, it does not seem probable that the public are likely to benefit very much by further discoveries of oil-bearing districts. Dr. Diesel during the last years of his life was greatly interested in the question of procuring suitable fuel for the Diesel design of engine, and closely investigated the possibilities of using vegetable oils, such as the so-called nut oil. However, so far there is little information available as to the cost of cultivation per acre or the price of the oil per ton, and for the present the only fuel available for Diesel engines may be regarded as some grade of petroleum, or some of the products distilled from tar.

This book will probably find its way on to the shelves of most engineers interested in internal combustion engines, and in many respects may be regarded as quite a useful addition to the literature on the subject.

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### Foundry Machinery.

By E. Treiber. Translated and revised by Chas. Salter. Scott, Greenwood and Son, London. 3s. 6d. net.

It is of course impossible to deal at all exhaustively with such a subject in so small a volume as the one before us. However, no such claim is made for it, but it is intended to deal briefly and simply with the more important

machines used in foundry practice, and as an introductory text book for the student it seems to answer its purpose, though as might be expected it deals chiefly with German practice. It can in no sense be said that it is intended to advertise any particular manufacturer, for the names of the makers of the machines actually illustrated are not even given—a needless omission we consider. It is another of the well-known "Broadway" series of engineering handbooks.

**Dictionary of German-English and English-German.**

By Max Bellows. Longmans, Green and Co., London. 6s. net.

The special characteristic of this work is the inclusion of a very large number of technical and scientific expressions not found in the ordinary dictionary, and so it will probably be useful to engineers. Its arrangement includes many novel features which are covered by the copyright, such as the distinguishing of genders by different types and the arrangement of the German-English and English-German concurrently on the same page. Personally we think that these departures do not add to the facility of ready reference and rather tend to confusion, but this impression might be overcome with longer acquaintance. There is, however, some information as to grammar and weights and measures equivalents included, not usually found in dictionaries, and this is certainly very useful.

**The Gas Works' Directory and Statistics, 1913-14.**

Hazell, Watson and Viney, Limited, London. 10s. 6d. net.

This is the 36th year of publication and in spite of the growing use of electricity its usefulness and scope are by no means limited. As usual, the particulars on all the usual headings are thoroughly revised and brought up to date. For those not familiar with this volume we may say that there is a general index of all officials connected with gas lighting works and a directory of, and statistics relating to all gas works in the United Kingdom, and information concerning all foreign and Colonial Gas Companies having offices in London, as well as a list of Associations connected with the industry.

**Principles and Processes of Metal Plate Work.**

By Edwin G. Barrett. Crosby, Lockwood and Son, London. 1913. 2s. 6d.

This little handbook is really intended for those students preparing for the examination in metal plate work of the City and Guilds Institute, of London, but, of course, its usefulness is by no means confined to such. In a recent report of the examiners attention is drawn to the general weakness of students in such subjects as knowledge of tools and mensuration. The author has therefore devoted special attention to these points. There are in addition chapters dealing with the production of metals and alloys used in plate work, their chemical and physical properties, solders and fluxes, turning and galvanising, and repair work. The syllabus of the examination, specimen questions and answers, and miscellaneous notes and tables conclude this well illustrated, simply written and eminently practical text book.

**Screw Cutting for Engineers.**

By Ernest Pull, A.M.I.Mech.E., M.I.M.E. Crosby Lockwood and Son, London. 1913. 2s. 6d. net.

This is another text book of the same series as the foregoing and, like it, deals in a practical manner with the subject treated. It is intended not only for students, but for practical mechanics, and contains numerous illustrations.

**The "Mechanical World" Pocket Diary and Year Book for 1914.**

Emmott and Co., Ltd., Manchester. 6d. net.

This well-known little diary enters on its 27th year of publication—a fact which is sufficient evidence of its usefulness. As usual, numerous new tables and improvements are embodied and the whole is really marvellous value for the modest sum charged for it.

# SHIPBUILDING AND MANUFACTURING NEWS

### The "Monte Penedo."

FURTHER interesting details are to hand of the results achieved by this motor ship which we described at considerable length in our issue of October, 1912. Her last trip was from Victoria, Brazil, to New York, a distance of 4,510 miles, which she covered in 17 days, 13 hours, without a stop. A correspondent, who inspected the vessel on her arrival, writes as follows :—

"I got aboard the ship shortly after she docked at Pier 26, in Brooklyn, on July 11th, 1913. My first visit was to the engine room, and the engines certainly made a very good impression, and cannot have looked better on the test floor of the manufacturer. Another proof of the good condition of the engines may be gained from the fact that practically no repair work, out of the ordinary, had to be done at all, and the engineers and helpers were free to go on land on the day of arrival in port. The same conditions as prevailed for the main engines apply also to the two auxiliary sets.

"In order to inspect a cylinder head and a piston, one cylinder head had been taken off and the piston taken out and dismantled. The wearing surfaces on the piston, piston rings, and especially in the cylinder, were in perfect condition ; the latter as smooth as a mirror. The parts of cylinder cover and piston forming the combustion space appeared black, as if covered with a thin coat of paint, no unduly large carbon deposits being visible. Neither was this the case in the exhaust ports. The fingers would not get blackened by reaching into them. No troubles were experienced on any of the main bearings, pins, or crosshead-guides. The parts requiring the most attention were the valves for the cooling water, and bilge pumps, and for the air compressor. The fuel pump packing seemed to be tight, and no leakage was visible."

### Fire Extinction on Ships.

IN view of the *Volturno* disaster, a recent demonstration of the Halley fire extinguishing and fumigating apparatus, at which we were present, was particularly interesting.

The demonstration took place at Glasgow, on board of the new steamer *Radja*, which has been built by Messrs. Wm. Hamilton and Co., Port Glasgow, for the Nederland Steamship Co.

The "Halley" apparatus, for which sulphur dioxide gas is the medium, consists of a gasifier, steam engine and blower, all placed together on one soleplate, occupying very little floor space, and on this particular ship is accommodated in a small house placed on the boat deck.

The S.O.2 is carried in liquid form in steel bottles, which are connected direct to the gasifier, in which the

liquid is gasified by means of hot air which is available in the case of fire from the hold, or steam may be used, should there be insufficient heat. Steam, of course, is used entirely when fumigating only. The gas thus generated is blown into the bottom of each hold, displacing the air and thus depriving the fire of the oxygen necessary to support combustion.

The hot air suction from the hold is placed near the top, and on the opposite side from the discharge inlet, thus causing a fair circulation of the gas.

At the demonstration, a dozen naphtha flares were placed at intervals in the otherwise empty hold, a few live rats, fruit, etc. The hold was made as air tight as possible, and a plate glass placed over a manhole, through which the flares were visible. The machine was started, discharging the fire-extinguishing gas almost immediately into the hold. After about an hour the flares were seen to be extinguished, and later, it was ascertained that the rats had been asphyxiated.

The demonstration proved the system to be at once an effective fire-extinguisher and destroyer of rats and vermin, and if one may judge by the pungency of the gas an excellent fumigator.

It also proved that the damage which may be done to a cargo by $SO_2$ gas is infinitesimal, compared with the damage which would be done with water or steam.

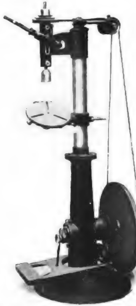
The great advantage of having the $SO_2$ in liquid form over the solid sulphur, is that the gas can be generated much more quickly, and less time is lost in getting to work once a fire has been discovered. Moreover, in the Halley apparatus no special cooler is necessary.

The apparatus is British made, and the installation was carried out by the Welin Davit and Engineering Co., Ltd., London.

### New Sensitive Drilling Machine.

AMONG the many exhibits of tools and accessories at the Motor Show, that of Messrs. Drummond Bros., Ltd., of Guildford, was one of the most interesting.

A really reliable drill is constantly needed in garage work, and to meet this need and to overcome the objection to most foot drills, which so often need an excessive amount of labour to drive, Messrs. Drummond have produced a drill specially constructed for this class of work.



NEW DRILLING MACHINE FOR GARAGE WORK, MADE BY MESSRS. DRUMMOND BROS., LTD., WORPLESDON, GUILDFORD, SURREY.

In this machine, which we illustrate, the fly wheel is of greater weight than usual, and its spindle runs on two S.K.F. ball bearings of ample size, accurately held in a rigid single casting, bolted as a separate unit to the pedestal. The drill spindle runs in phosphor bronze bushes, and the driven pulley runs on a similar bush rigidly held in the head, relieving the spindle of the belt strain.

The tool is throughout of more careful design, finish and workmanship than is usually found in this type

THE MEDWAY FLOATING DOCK CONSTRUCTED FOR THE ADMIRALTY BY MESSRS. SWAN, HUNTER & WIGHAM RICHARDSON, LTD.
THE PHOTOGRAPH SHOWS H.M.S. "LION" (10,500 TONS) LIFTED.

of machine. The spindle is fitted with a self-centering drill chuck of first-class quality. The table is made to swivel at any angle, and can therefore be used in a vertical as well as a horizontal position or at any desired angle, enabling many jobs, otherwise awkward to hold, to be easily fixed without the use of an angle plate.

Another exhibit of the same firm was a useful electric tool grinder, which can be operated by plug connection to an ordinary electric light socket. It is small and compact, and its power in relation to its size is really wonderful. It is, however, solidly constructed, with a well-designed base, which can easily be fixed to the bench, and should prove of great value in garages and repair shops.

### Floating Docks.

Messrs. Swan, Hunter & Wigham Richardson, Ltd., have just issued an extremely interesting booklet dealing exclusively with floating docks. Many illustrations and full particulars are given of various docks they have constructed for all parts of the world.

The illustration on page 424 shows the British Admiralty Dock in the River Medway built by this firm, with H.M.S. *Lion* lifted.

When the battle-cruiser, H.M.S. *Lion*, was placed on the Medway dock for the lifting trial she was displacing close on 30,500 tons, and drawing 31 ft. 6 ins. Taking into account the height of the keel blocks of the dock, the total distance through which the battle cruiser was lifted was 36 ft. In order to raise the deck of the dock clear of the water about 46,000 tons of water had to be pumped out, and this operation took a little more than three hours, which was well within the time limit prescribed by contract. After H.M.S. *Lion* had been scraped down and painted, and some small repairs had been effected, the dock was lowered first thing the next morning, and the ship was undocked during the day. The lifting and undocking of this great battle-cruiser created much interest, as at the time no ship of so large a displacement had ever been lifted out of the water by a floating dock.

### Motor Launch for S. America.

An interesting ceremony took place last week upon the occasion of the delivery to the Venezuelan Oil Concessions, Ltd., of a Thornycroft motor launch, which will be used in connection with their work on Lake Maracaibo.

The boat, which is named *Alves*, was designed and built by Messrs. John I. Thornycroft and Co., Ltd. She is 30 ft. in length by 7 ft. beam, with a draught of 2 ft. The hull is of teak, and the engine, which is of the Thornycroft M/2 type, developing 15 b.h.p. on paraffin, is fitted forward. The fuel tanks are placed under the forward deck. A folding spray-hood is fitted as a protection in rough weather. At the aft end, cushioned sheets are arranged to accommodate several persons. Two steering wheels are fitted, one forward; and a second wheel is within easy access to the reverse lever and throttle handle, thus providing for single-handed control.

Though the trial journey was made against the tide, it was accomplished in good time, notwithstanding the fact that a party of thirteen were on board.

### H.M.S. "Liberty."

H.M.S. *Liberty*, the second of the two T.B. Destroyers being built by J. Samuel White and Co., Ltd., for the 1912-13 programme is 260 ft. in length, and has a displacement of about 900 tons. The machinery is of the Parsons' impulse and reaction turbine type, receiving steam from 3 White-Forster water-tube boilers burning oil fuel. All the machinery has been constructed at Messrs. White's works.

### A New Stop Push Button.

It is often of vital importance to stop machinery instantly.

In a sudden emergency a slight delay may easily cause loss of life. For this reason the action of any device used to obtain an emergency stop must be sure and dependable. Yet many of the

push buttons provided for stopping electrical machinery are the reverse of reliable, because they aim at short circuiting the no-volt magnet coil of the starting switch instead of breaking its circuit.

The "Igranic" patent distant stop push button is intended to solve this difficulty. It has two sets of contacts—one set normally closed and the other set normally open. The normally closed contacts place the no-volt magnet coil in series with the shunt field. The normally open contacts, if closed, would provide a path for the field current independent of the no-volt magnet coil. When the button is pressed to stop the motor, it first closes the normally open contacts thereby providing an independent path for the field current, and then opens the normally closed contacts, thus breaking the circuit of the no-volt magnet coil.

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### "Watchman" Circuit Breaker.

THE advantages of automatic circuit breakers over fuses in power service, or even in larger lighting services, are widely appreciated, but the obstacle in the way of their more extensive use has always been cost. The efforts of switchgear makers have been directed to the production of a cheap article to fulfil the functions of a fuse, and Messrs. Switchgear and Cowans, Ltd., Salford, Manchester, after devoting much time to this question, and making numerous experiments, have produced a circuit breaker which, while very low in price, possesses all the features approved in high-class circuit breaker construction. The "Watchman," as their new circuit breaker is called, is built entirely on the metal and mica principle, is enclosed in a strong cast iron case, and being operated by a free handle, protects both consumer and supplier of power from damage to their property through closing the circuit on an overload or dead short. A fuse, of course, does not provide such safeguard, moreover customers cannot always be trusted to require a fuse. Bow-shaped laminated copper brushes, renewable auxiliary contacts and carbon breaks are further details which help to make the "Watchman" a thoroughly sound breaker. It should commend itself to station engineers, because it can be set to operate instantaneously at a definite current which does not vary as time goes on; because, if instantaneous action is not desirable, adjustable delay may be

THE "WATCHMAN" CIRCUIT BREAKER MADE BY MESSRS. SWITCHGEAR & COWANS, LTD., SALFORD.

obtained by the application of Statter's patent timelag, in which case the "Watchman" acts like a fuse, except that the amount of lag is under control; because adjustment having been made, the cast iron case may be sealed. As Messrs. Switchgear and Cowans anticipate a large demand for these circuit breakers they are kept in stock in two sizes, 30 amperes and 150 amperes, drilled for ¾ conduit and ready for immediate delivery.

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### Launch of s.s. "Eburna."

ON the 14th October Messrs. Swan, Hunter and Wigham Richardson, Ltd., launched from their Wallsend yard the sixth ship that they have built in recent years for the Anglo-Saxon Petroleum Company of London.

The vessel is the s.s. *Eburna*, a steel two-deck tank steamer, 392 feet long, with a breadth of 52 feet 9 inches, and designed to carry over 7,000 tons on a moderate draught. The *Eburna* has been built on the Isherwood system of longitudinal framing. The engines of triple expansion type, and also the boilers, are being built by The Wallsend Slipway and Engineering Co., Ltd., and will be placed in the after end of the vessel. The seamen and firemen will be accommodated in the forecastle, and the engineers in the after end of the ship. In the bridge house amidships quarters will be provided for the captain and officers. The various holds for carrying oil are separated by transverse and longitudinal oiltight bulkheads. Amidships is a pump room, and at each end of the range of oil holds is a cofferdam. Arrangements will be made for steaming out the oil tanks, and also for installing steam heating coils in each oil hold to thin heavy oils that may be carried. The small steam and motor launches of the shipyard and engine works easily berthed the *Eburna* alongside the Wallsend shipyard directly after she had become water borne.

### Aluminium for Motor Car Construction

SOME of the many uses of aluminium in the above connection are described and illustrated in an interesting booklet just issued by the British Aluminium Co., Ltd., of 109, Queen Victoria Street, London. In recent years the demand for the metal for this class of work has become increasingly heavy, and the company has greatly enlarged the scope and extent of its factories, and is now equipped for turning out ingots, plates, sheets and tubes. Special plant has also been laid down for the production of the large variety of sections needed in motor construction. An interesting table gives the comparative weights of brass, copper, steel and aluminium plates. Photographs of various castings and much useful data are also included in this list, which will be sent to all interested on request.

### Citroen Gears.

THE firm which manufactures these well-known gears, formerly known as André Citröen and Co., has been incorporated, and will in future be known as The Citröen Gear Co., Ltd. The address will remain as before, *i.e.*, 27, Queen Victoria Street, London, E.C., and no change will take place in the internal organisation owing to the incorporation, each gear receiving the same amount of personal attention and being as scientifically designed and cut as before.

## PERSONAL.

We learn that Mr. Charles H. Luke, R.M.S.E., A.I.E.S., until recently director and manager of the *Engineering Review*, has severed his connection with that journal, and will in future devote himself entirely to technical exhibition work. He has become a joint managing director of Walter Cawood, Ltd., the well-known exhibition organisers, and his private address is now Roslyn, Welmslow, Cheshire.

## NEW CATALOGUES.

### Thermofeed.

Ronald Trist and Co., Ltd., have just issued a booklet dealing exhaustively with their well-known Thermofeed regulator and controller for steam boilers. The claim is made, and is supported by conclusive evidence, that the cost of the Thermofeed on an average is repaid within six months, and that this same economy is made every subsequent six months. This is effected by the evaporation of a given extra amount of steam for the same quantity of fuel, by maintaining automatically, a uniform working level in the boilers. Such a claim deserves attention from all steam power users, and Messrs. Ronald Trist and Co. are prepared not only to send a representative to fully explain the system, but to allow a sixty days' trial of the regulator. We certainly advise all such who have not already proved for themselves the merits of this apparatus to commu-

nicate with the makers, at 4, Lloyd's Avenue, London.

### Oil Fired Boilers.

Messrs. Cochran and Co., Annan, Ltd., of Annan, Scotland, have sent us a descriptive booklet of their oil firing systems. In spite of the comparatively high price of oil, this form of firing presents many advantages, which will be accentuated when the price regains its normal level. Messrs. Cochran have for some time specialised in oil firing for both land and marine boilers, and the booklet before us, by means of diagrams explains clearly the various systems employed, more particularly in connection with the well-known Cochran boilers, prices of standard sizes of which are given. All interested in this question would do well to write to Messrs. Cochran, who will be glad to furnish full details.

### Electric Lifts.

The fourth edition of "Notes on Electric Lifts," issued by Smith, Major and Stevens, Ltd., of London and Northampton, is a record of results actually obtained in practice. It has been brought right up to date, and embodies details of all the latest improvements and safeguards in lift working. There are very many illustrations of different types of lifts, engines, controllers, cages, and buildings all over the world where these well known lifts have been installed. Costs of working, repairs and upkeep, and contrasts with other systems of lift working are given, as well as much other interesting information. Before deciding on any system it would be well for anyone contemplating a lift installation to send for this book. Messrs. Smith, Major and Stevens will be glad to render any assistance in the choice of a service. The excellence of their workmanship and reliability of their products are testified to by very many satisfied users.

### Vickers Limited.

This firm has just issued a special brochure describing and illustrating by excellent photographs, their exhibit at the Ghent Exhibition. An effort was made to render this exhibit especially representative, and this was certainly achieved; motor cars, machine tools, electrical apparatus, aeroplane and marine engines, metal work, etc., were included in this display, which worthily upheld the traditions of British engineering.

Subscription, 12s. per year. Post Free.

Vol. 44, No. 6. ONE SHILLING. December 1913.

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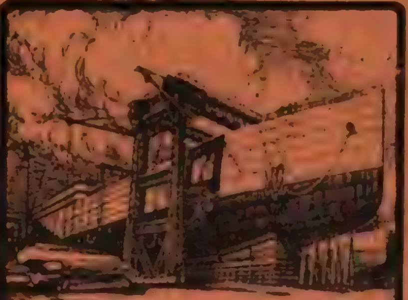

December

For Contents see Page 2.

## ENGINEERING SHIPBUILDING

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For contents see page 2.

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## CONTENTS FOR DECEMBER, 1913.



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**For Index to Advertisers see pages 29, 30, 32 and 34.**

**For Classified Buyers' Guide see Blue Index at the end of the Journal.**



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New Copy for Advertisements, alterations, &c. should reach us not later than the morning of the 14th of the month preceding that in which such changes and alterations are required to be made, otherwise, while we do all in our power to make any changes or alterations, we cannot guarantee to do so.

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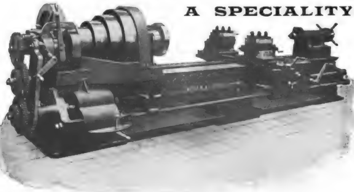

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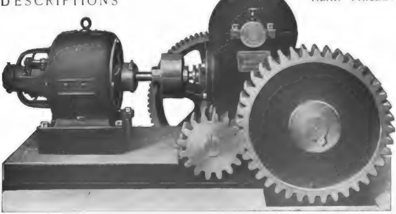

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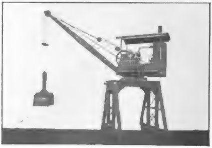

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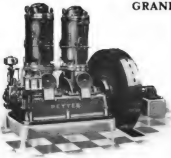


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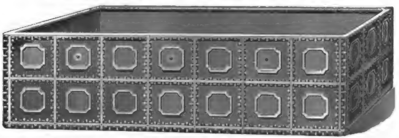

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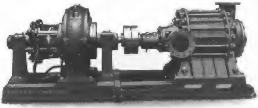

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# CASSIER'S ENGINEERING ABSTRACTS

**DECEMBER, 1913.**

**Edited by Dr. C. Kinzbrunner**

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All the most important articles of permanent value published in the Transactions of the Engineering Societies, and in all engineering journals of the world, are indexed and abstracted; in the case of articles published in foreign languages, the index is given in English, but the original title is also printed.

The following information is given about every publication :—

1. Title of article.
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3. Name of author.
4. Where published, title of periodical, volume and number.
5. In cases where the title is not self-explanatory, an abstract is given, the length of which varies according to the importance of the article.
6. Price of original article.
7. A consecutive number for the purpose of facilitating the ordering of papers.

We are ready to supply the full text of every article indexed, in the original language, together with all illustrations; our charges are given at the end of each abstract. Where no price is stated, the copies are not readily obtainable; in such cases prices will be governed by the cost at which these journals are published. A remittance should accompany all orders.

We can also supply abstracts of all articles indexed, in English; the charges for these vary according to length and difficulty.

Full translations of articles, together with all illustrations, can be procured; charges on application. In all enquiries consecutive number of article must be given.

For the sake of convenience, the index is classified into the larger sections of Mechanical Engineering. Each Section is again divided into sub-sections, which are arranged alphabetically. Thus it is possible to trace at once all articles upon the subjects claiming one's special interest.

Note.—Unless otherwise requested only the particular article mentioned will be sent and not the whole journal in which it occurs. It is only necessary in ordering to give the serial number of the Abstract.

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**Co-operation of the Allied Electrical Industries from the Standpoint of the Electrical Contractors.** GILLILAND, G. A. "El. Rev. Chic." Vol. 53, 13, pp. 615-18. 1s. 3d. No. 8175

**The Future of the Engineer in the Orient.** SCHMIED, F. (Die Zukunft des Technikers im Oriente.) "Z. Oest. Ing. Arch. V." Vol. 65, 29, pp. 455-6. 1s. 6d. No. 8176

**Progress of Engineering in the East.** "Engineer." Vol. 106, 3,015, pp. 378-9. Ill. (Tsingtau Harbour, Shantung, China). 1s. No. 8177

**The Concentration of the German Industry more especially of Coal Mining.** JUENGST, E. (Die Konzentration im deutschen Wirtschaftsleben, im besonderen im Steinkohlenbergbau.) "Glueckauf." Vol. 49-35, pp. 1,464-77. 2s. 6d. No. 8178

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**A Portable Engine.** "Int. Comb. Eng." Vol. 3, 56, p. 659. (Particularly suitable for all classes of agricultural work.) 1s. No. 8299

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**Gasoline Engine Troubles and their Symptoms.** BRENNAN, A. L. "Power." Vol. 38, 13, pp. 432-4. Ill. 1s. No. 8301

**The Direct Reversing of Combustion Engines.** POHLMANN. (Die unmittelbare Umsteuerung der Verbrennungskraftmaschinen.) "Verhdlg. Ver. Befoerd. Gewerbfl." 1913, 7, pp. 309-92. Ill. 5s. 6d. No. 8302

**The Gas Turbine.** VENTOU-DUCLAUX, L. "Cass. Eng. Mly." Vol. 44, 4, pp. 215-29. 1s. No. 8303

**The Rockefeller Sleeve Valve Engine.** "Autocar." Vol. 31, 937, p. 627. Ill. (Reported entry of the Standard Oil Co. into motor manufacture.) 6d. No. 8304

**Two-Cycle Motors.** PRAETORIUS (Zweitaktmotoren.) "Motorwagen." Vol. 16, 20, pp. 498-500. Ill. 21, pp. 521-8, 23 pp. 567-71. (Description of different types). 6s. No. 8305

**The Johnson and Smith Four-Cylinder Engine.** "Cyclecar." Vol. 2, 45, pp. 477. Ill. (Two valves under each valve cap and a three bearing crankshaft.) 6d. No. 8306

**The New 9-10 H.P. Four-Cylinder Blumfield Engine.** "Cyclecar." Vol. 2, 45, pp. 476. Ill. 6d. No. 8307

**Cam Design for Automobile Engines.** BOWER, G. S. "Int. Comb. Eng." Vol. 3, 56, pp. 673. Ill. (The characteristics of various profiles.) 1s. No. 8308

**Inspection of Gas Engines.** TOOKEY, W. A. "Gas World." Vol. 59, 1523, pp. 380-1. No. 8309

**An Energy Chart for Gas.** MORLEY, T. B. "Engineering." Vol. 94, 2492, pp. 445. Ill. 1s. No. 8310

**Automobile Motor Investigations.** STROMBECK. (Untersuchungen an Automobilmotoren.) "Oelmotor." Vol. 2, 3, pp. 205-13. (The concluding article on this subject deals with the investigation of the exhaust gases, the indicating of the motors the investigation of a motor with semi-spherical compression chamber a comparison of the motors tested, investigation of the fuel, &c.) 3s. 6d. No. 8311

**Test of Automobile Engines.** "Munic. Jl." (Twelve hour durability test of eleven automobile pumping engines by the International Association of Fire Engineers.) 1s. No. 8312

**Testing 25,000 Motors a Year.** "Automobile." Vol. 29, 14, p. 594. Ill. (Continental's new testing room includes all modern motor-testing devices. Silence rooms added.) 1s. No. 8313

**The Dorman Two-Cylinder Engine.** "Motor Cycle." Vol. 11, 549, pp. 1275. Ill. (Single-piece cylinder casting; 9 B.H.P. at 1,500 r.p.m.) 6d. No. 8314

RIME MOVERS.

**Graphodynamical Test of an Four-Cylinder Autocar Engine with Variable Stroke (Type Gill & Aveling, England.)** NERRETER, A. (Graphodynamische Untersuchung einer vierzylindrigen Fahrzeug maschine mit veränderlichem Hube). "Motorwagen." Vol. 16, 20, 21, pp. 528-31; pp. 501-5. Ill. (Results of test, features of the type Gill & Aveling, criticism thereon.) 4s. No. 8315

**"Le Rhone" Motor.** SEEKATZ, FR. WM. (Der Le Rhône Motor.) "Motorwagen." Vol. 16, 23, pp. 585-6. Ill. (Make of the French Gnome Motor Company; superior to the Gnome Motor.) 2s. No. 8316

POWER PLANT.

**Good Record for Small Isolated Plant.** JOHNSON, F. L. "Power." Vol. 38, 14, pp. 456-8. Ill. (With a rate of 2c. per kw. hr. for power and 8 c. for lighting from the central station and doing its own heating, the Renton Heel Co, decided to instal a 75 kw. generating set. With coal at $3.50 per ton it made a gross annual saving of 27 per cent. or a net earning on the investment of 18 per cent.) 1s. No. 8317

**The "Ruetz" Power Station of the Mittenwald Railway.** REINDL, C. (Das "Ruetz-Elektrizitaetsweck "der Mittenwalder Bahn.) "Z. ges, Turbinenwes." Vol. 10, 26, pp. 404-10. Ill. 27, pp. 417-23. Ill. 5s. No. 8318

**Power Plant of Chester Valley Electric Co.** ROGERS, W. O. "Power." Vol. 38, 15, pp, 490-2. Ill. (Example of a small central station, carrying a mixed electrical road.) 1s. No. 8319

**The Chester Hydro-electric Plant.** "El. Rev." Vol. 73, 1873, pp. 619-22. Ill. 1s. No. 8320

**Extension of the Great Western Power Company in California.** HOMBERGER, H. (Erweiterungsbauten der Great Western Power Company in Kalifronien.) "Z. ges Turbinenw." Vol. 10, 20, pp. 306-9. Ill. 2s. No. 8321

**The Electricity Works of the Lister-Valley.** TREIBER, E. (Das Elektrizitaetswerk an der Listertalsperre.) "Z. Ges. Turbinenw." Vol. 10, 22, pp. 337-8. 2s. No. 8322

**The Power Transmission Plant Lauchhammer-Groeditz-Riesa.** (Die Kraftuebertragungsanlage Lauzhhammer-Groeditz-Riesa.) "Z. Ver. D. Ing." Vol. 57, 31 pp. 1,205-11. Ill. 2s. 6d. No. 8323

**Puntledge Hydroelectric Power Plant.** "Eng. Rec." Vol. 68, 12, p. 312. Ill. (An ultimate development of 19,000 H.P., which will supersede separate steam plants used for the operation of coal mines at Vancouver Island.) 1s. No. 8324

**Power Transmission Schemes Trollhattan-Kopenhagen.** JENSEN, J. JOHS. (Kraftue bertragungsprojekte Trollhättan-Kopenhagen. "ETZ." Vol. 34, 39, pp. 1,115-17. (Power consumption at Copenhagen; cost of plant and working of power transmission.) 3s. 6d. No. 8325

**Hydro-electric Plant of 300,000 H.P. of Keokuk, at the Mississippi (Iowa U.S.).** CALFAS, P. (Usine hydroelectrique, de 300,000 Chevaux, de Keokuk.) "Gen. Civ." Vol. 63, 13, pp. 245-8. Ill. (The plant utilises the height of fall of 9.75 m. caused by a dam of 1,417 m. length; 30 turbines of 10,000 H.P. each will be installed, the costs amounting to 125,000,000 frcs.). 2s. 6d. No. 8326

**Oil Motor Power at Leipzig Building Exposition.** GRADENWITZ, A. "Power." Vol. 38, 12, p. 396. Ill. 1s. No. 8327

**Power Works Whylen of the Power Transmission Works Rheinfelden.** **Frey, E. Albrecht, O.** (Das Kraftwerk Wyhlen der Kraftübertragungswerke Rheinfelden A.G.). "ETZ." Vol. 34, 37, pp. 1,048-53, 38, pp. 1,087-90; 39, pp. 1,108-12; 40, pp. 1,141-43. 14s. No. 8328

STEAM ENGINES.

**A Single Cylinder Compound Engine.** "Power." Vol. 38, 12, pp. 413-4. Ill. 1s. No. 8329

**The Uniflow Cylinder Adapted to Locomobiles.** MILLER, W. H. "El. World." Vol. 62, 14, pp. 689-91. Ill. (Utilization at the undirectional steamflow scheme for minimizing cylinder condensation in self contained units using saturated or superheated steam.) 1s. No. 8330

**The 500 H.P. Superheated Steam Compound Locomobile of the Lanz Type.** (Die nominell 500 P.S. Heissdampf Berbund-Lokomobile Bauart Lanz.) "Uhland. Spec. Ed." II., pp. 51-3. Ill. (Description of stationary machine which is shown at the exhibition at Leipzig.) 2s. 6d. No. 8331

**800 B.H.P. Compound Condensing Superheated Steam Locomobile.** "Engineering." Vol. 94, 2,492, p. 455. Ill. 1s. No. 8332

**Trip Gear for Operating the Admission Valves of Steam Engines.** "Mech. Eng." Vol. 32, 819, pp. 308-9. Ill. 1s. No. 8333

**The Drop-Valve Engine in its Modern Development.** "Mech. World." Vol. 54, 1,396, p. 163. 6d. No. 8334

STEAM TURBINES.

**Contributions to the Theory of Turbines for Elastic Driving Means.** BAETZ, KONRAD. (Ergänzungen zur Theorie der Turbine für elastische Treibmittel.) "Uhland. Spec. Ed." II., pp. 53-55. Ill. 2s. 6d. No. 8335

**Recent Developments in Curtis Steam Turbines.** HALLIWELL, R. F. "Vulcan." Vol. 10, 112, pp. 73-5. 9 fig. 1s. No. 8336

**The Ljungstrom Turbine.** "El. Times." Vol. 44, 1,147, pp. 349-50. Ill. 6d. No. 8337

**Exhaust Steam and Two-stage Turbines.** ROEDER K. (Die Abdampf-und Zweidruckturbinen.) "Z. ges. Turbinenw." Vol. 10, 16, pp. 248-51. Ill.; 17, pp. 266-70. Ill.; 18, pp. 277-284. Ill. 6s. No. 8338

**The Steam Consumption of Exhaust Steam and Two Stage Turbines under Various Working Conditions.** ROEDER, K. (Der Dampfverbrauch der Abdampf- und Zweidruckturbinen bei den verschiedenen Betriebs-verhaeltnissen.) "Z. Ver. D. Ing." Vol

**PRIME MOVERS.**

57, 27, pp. 1,065-74. Ill. 2s. 6d. No. 8339

**The Steam Friction of Turbine Wheels.** KERR, W. "Mech. Eng." Vol. 32, 821 p. 364. 1s. No. 8340

**The Calculation of Disc Wheels.** HOLZER, H. (Die Berechnung der Scheibenraeder.) "Z. ges. Turbinenwes." Vol. 10, 26, pp. 401-4. Ill.; 27, pp. 424-7. Ill. 5s. No. 8341

**The Development of Steam-Turbine Building and Its Present State.** SCHWARZWEBER, O. (Die Entwicklung des Dampfturbinenbaues und seine heutige Lage.) "Z. ges. Turbinenw." Vol 10 19, pp. 289-3. Ill.; 20, pp. 309-13. Ill.; 21, pp. 327-30. Ill. 6s. No. 8342

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**A Large High-Speed Water Turbine.** THOMA H. (Eine grosse Schnellaeuferturbine.) "Z. Ver. D. Ing." Vol. 57, 28, pp. 1,108-11 Ill. (Output 3,000 H.P.). 2s. 6d. No. 8343

**The Blade Surfaces of High-Pressure Free-Jet Turbines.** BAUDISCH, H. (Die Schaufelflaechen der Hochdruckfreistrahlturbinen.) "Z. ges. Turbinenw." Vol. 10, 23, pp. 353-7. Ill. 2s. No. 8344

**3,000 H.P. Turbine with Spoon-shaped Blades.** (Die 3,000 Ps. Löffelturbine des Arniwerks.) "Uhland. Spec. Ed." II., 8, pp. 45-7. Ill. Height of fall, 600 m., rev.p.m., 630.) 2s. 6d. No. 8345

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**Absolute Pressure Thermometer.** PHILLIPS, W. H. "Power." Vol. 38, 12, pp. 415. Ill. (By the use of a special thermometer one is enabled to read the temperature of steam in degrees F. and the absolute pressure in inches of the saturated steam in a turbine exhaust head.) 1s. No. 8346

**The Venturi Steam Meter.** RICHARDSON, C. G. "Power." Vol. 38, 15, pp. 493-5. Ill. 1s. No. 8347

**New Measuring Devices for Pressure and Velocity of Gases and Vapours.** LUETKE, H. (Neue Messgeraete fuer Druck und Geschwindigkeit von Gasen und Daempfen.) "Stahl Eisen." Vol. 33, 32, pp. 1,307-10. 3s. No. 8348

**Torsion Dynamometer with Optical Reading Device.** VIEWEG, V. (Torsions-Dynamometer mit optischer Ablesevorichtung.) "Z. Ver. D. Ing." Vol. 57, 31, pp. 1,227-9. Ill. 2s. 6d. No. 8349

**Maihak Indicator and Boettcher Efficiency Indicator.** "Power." Vol. 38, 13, p. 427. Ill. (Designed to be used especially with gas and Diesel oil engine.) 1s. No. 8350

**Accuracy of Results of Braking Tests with Air Brakes.** KATZMEYER, RICHARD. (Ueber die Genauigkeit der Bremsergebnisse bei Verwendung von Windflügelbremsen.) "Motorwagen." Vol. 16, 21, pp. 517-19. Ill. (The air brakes solve two problems: they load the engine and permit of a measurement of the developed moment of torsion. The author shows that this class of braking devices is equivalent to any other braking device so far as accuracy of measurement is concerned.) 2s. No. 8351

**A Torsion Meter with Visible Scale.** SUYEHIRO, K. "Engineering." Vol. 92, 2,492 p. 459. Ill. 1s. No. 8352

## IV.—Tools and Machine Tools.

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**Ghent Exhibition.** "Page's Wly." Vol. 23, 475, pp. 509-20. Ill. (Machine tools and other objects of interest in the British section.) 1s. No. 8353

**Small Tools. The Basis of Economic Manufacturing.** KAUP, W. J. "El. Jl." Vol. 10, 9, pp. 868-74. 1s. 6d. No. 8354

**Strains in Materials and Their Unfavourable Influence on Exact Machining.** KUYN, P. (Materialspannungen und deren unguenstige Einfluesse auf genaue Maschinenarbeiten.) "Werkstattstechn." Vol. 7, 17, pp. 525-6. Ill. 2s. 6d. No. 8355

**ACCIDENTS AND GUARDS.**

**Preventing Accidents from Machines.** KNEELAND, F. H. "Coal Age." Vol. 4, 14, pp. 480-3. Ill. (Descriptions and illustrations of some safety devices which have proved their merits in actual use at power plants, sub-stations and shops.) 1s. No. 8356

**BORING.**

**Boring Bars and Boring Heads.** HAAS, L. L. "Am. Machinist." Vol. 39, XI., pp. 445-8. 38 fig. (A large variety of boring bars and boring heads, together with dimensions, methods of holding blades and materials.) 1s. No. 8357

**Some Data Concerning the Rational Utilisation of Boring Machines.** HAASE, KARL. (Einige Beiträge zur rationellen Ausnutzung der Bohrmaschinen.) "Uhland. Spec. Ed." 1913, 15, pp. 171-3. 2s. 6d. No. 8358

**CUTTING.**

**Special Types of Cold-Saws (System Gustav Wagner Reutlingen) for Railway Material.** MULLER, EDUARD. (Sonderausführungen von Kaltsäge maschinen System Gustav Wagner Reutlingen) für Bahn Material.) "Glaser." Vol. 73, 4, pp. 71-74. (Description of the cold-saw; special types for cutting rails.) 2s. 6d. No. 8359

**DESIGN OF MACHINE TOOLS.**

**Experimental and Theoretical Researches on Compressed Air Tools.** GROEDEL, E. (Experimentelle und theoretische Untersuchungen an Pressluftwerkzeugen.) "Z. Ver. D. Ing." Vol. 57, 30, pp. 1185-8. Ill. 2s. 6d. No. 8360

**Adjustable Fixture for Holding Irregular Shaped Work.** "Machinery." Vol. 20, 2, p. 87. Ill. 2s. No. 8361

**Application of Electromagnetic Tripping Devices.** MEYNCKE, G. M. "Machinery." Vol. 20, 2, pp. 88-90. Ill. (Mechanisms which prevent damaging machines or producing defective work.) 2s. No. 8362

**Experiences in the Design of Chucks and their Application.** KNESING, A. (Erfahrungen im Vorrichtungsbau und deren Anwendung.) "Werkstattstechn." Vol. 7, 15, pp. 483-5. Ill. 2s. 6d. No. 8363

**TOOLS AND MACHINE TOOLS.**

**The Design of Heavy Duty Forging Machinery.** "Iron Tr. Rev." Vol. 53, 14, pp. 591-2. 6 fig. 2s. 6d. No. 8364

**DRILLING.**

**A Jig for Drilling Deep Holes in Bronze.** ALLEN, M. H. P. Vol. 39, 12, pp. 489-90. 7 fig. 1s. No. 8365

**Some Drilling Operations on Gasoline Engines.** "Am. Machinist." Vol. 39, XI., pp. 425-8. 12 fig. 1s. No. 8366

**Pneumatic Feed Air Drilling Machine.** HENRY, N. B. "Am. Machinist." Vol. 39, 12, pp. 469-70. 1 fig. 1s. No. 8367

**Comparison of Various Types of Radial Drills.** BRZOSKA. (Vergleichende Betrachtungen verschiedener Formen von Radialbohrmaschinen.) "Z. Werkzeugmasch." Vol. 17, 35, pp. 527-32. Ill. 2s. 6d. No. 8368

**Attachments for Sensitive Drilling Machine Tables.** HORNER, F. "Mech. World." Vol. 54, 1397, p. 170. 6d. No. 8369

**Improved 6 ft. Radial Drilling Machine.** "Iron Age." Vol. 92, 14, p 705. Ill. 2s. No. 8370

**Sensitive Drilling Machine with Ball-Bearings.** "Engineering." Vol. 94, 2493, p. 493. Ill. (Constructed by Messrs. A. A. Jones and Shipman, Ltd., Engineers, Leicester.) 1s. No. 8371

**DRIVING OF MACHINE TOOLS.**

**Electricity in Automobile Manufacturing.** "Electr. Rev. Chic." Vol. 53, 13, pp. 607-11. Ill. (The conditions regarding the application of motor drive and central station power to plants manufacturing automobile bodies.) 1s. 3d. No. 8372

**Flywheels of Electrically-driven Machine Tools.** VON SCHROCT, PAUL. (Schwungräder von elektrisch betriebenen Arbeitsmaschinen.) "Uhland. Spec. Ed." V., 9. pp. 5-6. Ill. 2s. 6d. No. 8373

**FORGING AND PUNCHING.**

**A 4-in. Heavy Pattern Forging Machine.** "Iron Age." Vol. 92, 14, p. 709. Ill. 2s. No. 8374

**Special Punching and Turning Operations.** COLVIN, F. H. "Am. Machinist." Vol. 39, 12, pp. 477-82. 16 fig. (Concrete gallery for dies and other tools, the punching of malleable iron castings and drop forgings and the fixtures for holding them, etc.) 1s. No. 8375

**Machine Forging.** HAMILTON, D. T. "Machinery." Vol. 20, 2, pp. 91-4. Ill. (Dies and methods employed in the forming, welding and upsetting of machine and engine parts.) 2s. No. 8376

**Modern Methods for Producting a Uniform and Straight Edge on Drawn Articles.** STOCK, R. (Moderne Arbeitsweisen, den Rand bei gezogenen Teilen gleichmaessig und gerade herzustellen.) "Werkstattstechn." Vol. 7, 17, pp. 521-3. Ill. 2s. 6d. No. 8377

**GAUGES AND MEASURING DEVICES.**

**Toledo Centre Finder.** "Power." Vol. 38, 13, pp. 424-5. Ill. 1s. No. 8378

**The Forms of Jointed Calipers.** HORNER, F. "Mech. World." Vol. 54, 1395, p. 146. Ill. 6d. No. 8379

**On the Measurement and the Accuracy of Screw Threads.** SIMON, E. (Ueber das Messen und die Genauigkeit von Gewinden.) "Werkstattstechn." Vol. 7, 17, pp. 515-20, 18, 551-5, 19. pp. 580-3. Ill. 7s. 6d. No. 8380

**Disk and Square Method for Determining Angular Settings.** GARDNER, G. H. "Machinery." Vol. 20, 2, p. 128. Ill. 2s. No. 8381

**GRINDING.**

**A Single Device for Re-Grinding Crank-Shafts on the Lathe.** GOTTWEIN, K. (Einfacher Apparat zum Nachschleifen von Kurbelwellen auf den Drehbank.) "Werkstattstechn." Col. 7, 17, pp. 526-7. Ill. 2s. 6d. No. 8382

**A Horizontal Surface Grinding Machine.** "Iron Age." Vol. 92, 13, p. 656. Ill. (New Pratt and Whitney machine for surfaces in different planes.) 2s. No. 8383

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**Grinding 'Wheels, Grinding Machines and Grinding.** MORGAN, K. D. "Page's Wly." Vol. 23, 473, pp. 444-6. Ill. 1s. No. 8385

**LATHES.**

**Car Axle Turner.** MARKEL, C. "Railw. Locom. Eng." Vol. 26, 10, pp. 349-52. Ill. 2s. No. 8386

**Work Holding Arbors and Methods for Turning Operations.** "Machinery." Vol. 20, 2, pp. 81-7. Ill. (A typical collection of devices especially designed for holding work in the Fay automatic lathe.) 2s. No. 8387

**Modern High Speed Lathe.** BECKER, K. (Moderne Schnelldrehbank.) "Uhland. Spec. Ed." 19, pp. 207-10. Ill. (A new headstock of a German high-speed lathe is described.) 2s. 6d. No. 8388

**14-in. Swing "Apollo" Combination Turret Lathe.** "Engineering." Vol. 94, 2,493 p. 494. Ill. 1s. No. 8389

**Twin Lathe for Machining Cocks.** COHN, E. (Doppeldrehbank zur Bearbeitung von Haehnen.) "Z. Ver. D. Ing." Vol. 57, 39, pp. 1,546-8. Ill. 2s. 6d. No. 8390

**MILLING.**

**The New Vertical Milling Machine, built by J. E. Reinecker A.G. in Chemnitz-Gablenz.** NICKEL, F. (Die neue Senkrecht-Fraesmaschine von J. E. Reinecker, A.G. Chemnitz-Gablenz.) "Z. Ver. D. Ing." Vol. 57, 36, pp. 1,409-14. Ill. 2s. 6d. No. 8391

**Standardising of High Power Milling Machines.** KELLE. (Normaliendurchfuehrung an Hockleistungsfraesmaschinen.) "Werkstattstechn." Vol. 7, 18, pp. 547-51. Ill. 2s. 6d. No. 8392

**An Italian Milling Machine.** HOANER, J. "Machinery." Vol. 20, 2, pp. 107-8. Ill. (A machine in which both speed and feed changes are derived from the same gear box.) 2s. No. 8393

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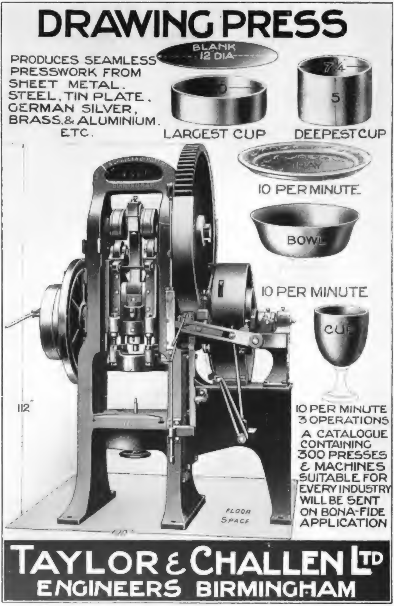
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**Milling Machines for Switch Blades.** PROSKE (Fräsmaschine fur Weichenzungen.) "Organ." Vol. 50, 18. pp. 326-29. Ill. 3s. 6d. No. 8395

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**PRESSES.**

**Calculation and Design of Screw Presses.** OELSCHLÄGER, JULIUS. (Berechnung und Konstruktion von Spindelpressen.) "Uhland." Vol. 46, 17, pp. 189-90. Ill.; 18, pp. 201-2. Ill. 2s. 6d. No. 8397

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**Setting Up Press Tools.** STEVENS, F. G. "Mech. World." Vol. 54, 1,397, p. 170. 6d. No. 8399

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**Electric Riveting.** "Boiler Maker." Vol. 13, 9, pp. 304-5. Ill. 1s. No. 8400

**Electric Floating-Drilling and Rivetting Machines.** SPROECKE, ROLF. (Elektrische Pendelbohr und Nietmaschinen.) "Uhland Spec. Ed." 17, pp. 183-8. Ill. 2s. 6d. No. 8401

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**Setting Up and Operating Automatic Screw Machines.** HAMILTON, D. T. "Machinery." Vol. 20, 2, pp. 129-34. Ill. (Application to the "Acme" multiple-spindle automatic screw machine.) 2s. No. 8402

**Automatic Finishing of Screw Nuts.** TSCHERNTSCHITSCH, J. (Automatische Fassonierung von Schraubenmuttern.) "Metallind." Vol. 5, 19, pp. 4-6. Ill. 1s. 3d. No. 8403

**Tests of Dividing Head Worms.** STRAUSS, W. O. "Am. Machinist." Vol. 39, XI., pp. 421-3. 5 fig. (A series of tests to determine the best materials; three grades of steel were tested, the analysis of each is given, and the wear on each thread is noted after being given the strenuous test.) 1s. No. 8404

**Stress Curves for Bolt Diameters.** DANIELS, A. M. "Am. Machinist." Vol. 39, 12, pp. 475-6. 1s. No. 8405

**SHOPS.**

**Partitions for Factories and Industrial Buildings.** TYRRELL, H. G. "Engin. Magaz." (N.Y.). Vol. 46, 1. pp. 53-62. 31 fig. (Framed partitions in which metal, or more rarely wood, takes the principal place.) 2s. No. 8406

**SPECIAL TOOLS.**

**Bevel Gear Cutting Machines without Chuck.** GALASSINI, A. (Kegelraederschneidmaschinen ohne Schablone.) "Werkstattstechn." Vol. 7, 18, pp. 560-3. Ill; 19, pp. 586-90. Ill. 3s. No. 8407

**Manufacturing Bevel Gears for Automobiles.** RAPSON, T. "Int. Comb. Eng." Vol. 3, 35, p. 635. Ill. 1s. No. 8408

**Special Machines for Auto Small Parts** COLVIN, F. H. "Am. Machinist." Vol. 39, XI., pp. 439-43. 11 fig. (Cutting of internal gears; how awkward pieces are held in the lathe; the use of a counter on a turret slide, punching the steering column base, etc.) 1s. No. 8409

**Planing Shoes and Wedges.** DICKERT, C. L. "Railway Age Gaz. Mech. Ed." Vol. 87, 10, pp. 537-8. 6 fig. 1s. 6d. No. 8410

**Making Large Guns and Projectiles.** "Am. Machinist." Vol. 39, 12, pp. 467-9. 5 fig. (Lathes confined to the making of coast defence and similar guns; description of the largest lathe yet built, which will swing a forging 102 in. in diameter and 73 ft. long.) 1s. No. 8411

**Machines and Tools for Quackenbush Rifles.** VIALL, E. "Am. Machinist." Vol. 39, 12, p. 483-7. 18 fig. (A special six-spindle rifle barrel drilling machine; testing the bore tools for making small brass packing rings, forming frame bosses, etc.) 1s. No. 8412

**TOOLS AND TOOL STEEL.**

**Modern Tool Steels and High-Speed Tool Alloys.** ARMSTRONG, G. S. "Engin. Magaz." (N.Y.). Vol. 46, 1, pp. 63-76. 13 fig. (Manufacture and mechanical treatment, applications of tool steel, and the grades and tempers of alloy and carbon steel suited for various purposes.) 2s. No. 8413

**The Testing of Machine Tools.** LANGNER, R. (Das Pruefen von Werkzeugmaschinen.) "Z. Oest. Ing. Arch. V." Vol. 65, 30, pp. 465-8. 1s. 6d. No. 8414

**Progress of German Steel Works in the Manufacture of Alloyed High-Speed Tool-Steels.** SCHLESINGER, G. (Die Fortschritte deutscher Stahlwerke bei der Herstellung hochlegierter Schnellarbeitsstaehle.) "Stahl. Eisen." Vol. 33, 23, pp. 929-39. Ill.; 29, pp. 1,196-1,204; 32, pp. 1,316-25. (Discussion of favourable influence of cobalt on the output and life of tool steels.) 9s. No. 8415

**Making Twisted Steel Bits for Wood Works.** VIALL, E. "Am. Machinist." Vol. 39, XI., pp. 429-33. 19 fig. (The use of friction disks for the removal of superfluous metal and forming the threads on leader screws.) 1s. No. 8416

**Correct Cutting Angles for High-Speed Steel Tools.** "Mech. World." Vol. 54, 1,398, pp. 182-3. Ill. 6d. No. 8417

**Resistance of Steel to Wear in Relation to Hardness and Strength.** "Machinery." Vol. 20, 2, pp. 109-10. Ill. 2s. No. 8418

**Metal Tools Made of Steel-Tool Holders with Small Pieces of Special Steel Welded or Soldered on.** (Metallbearbeitungswerkzeuge aus Stahlhaltern mit aufgelöteten oder aufgeschweissten Plättchen aus Spezialstahl. "Uhland Spec. Ed." 1913, 15, pp. 173-4. Ill. (Waste pieces can be employed.) 2s. 6d. No. 8419

**WELDING.**

**Repairing Cast-Iron Pump Cylinders by Autogeneous Welding.** (Reparatur eines gusseisernen Pumpenzylinders mittelst autogener Schweissung.) "Uhland." Vol. 46, 30, pp. 99-100. Ill. 2s. 6d. No. 8420

TOOLS AND MACHINE TOOLS.

**MISCELLANEOUS.**

**Automatic Tapping and Reaming Machine.** "Iron Age." Vol. 92, 12, pp. 606-7. Ill. (High production machine for finishing valve bodies, return bends, &c.) 2s. No. 8421

**Inspection Tests for Cincinnati Gear-Cutting Machines.** "Machinery." Vol. 20, 2, pp. 99-101. Ill. (Methods of testing alignment of different parts while gear-cutting machines are being assembled.) 2s. No. 8422

**Electric Heating for Engineering Purposes.** SCHULZ, W. (Elektrische Heizung im Maschinenbau.) "Z. Ver. D. Ing." Vol. 57, 28, pp. 1,092-1,101. Ill. (Description of industrial devices for heating air, liquids, &c.) 2s. 6d. No. 8423

**Points and Broach Making.** JONES, F. D. "Machinery." Vol. 20, 2, pp. 97-8. Ill. 2s. No. 8424

**Machine Vices.** BENTLEY, H. "Page's Wly." Vol. 23, 473, pp. 438-9. Ill. 1s. No. 8425

## V.—Materials and Testing of Materials.

**METALLOGRAPHY.**

**Mico-Structure of Crude and Malleable Iron.** ERBREICH, F. (Kleingefuege des Roheisens und des Schmiedbaren Eisens.) "Giesserei Z." Vol. 10, 18, p. 561-5. Ill. 19, pp. 603-6. 5s. No. 8426

**Microscopic Examination of Metals by Means of Polarised Light.** HANEMANN and ENDELL. (Ueber die mikroskopische Untersuchung von Metallen mittels polarisierten Lichtes.) "Stahleisen." Vol. 33, 40, pp. 1,644-6. Ill. 3s. No. 8427

**Structure of Mild Steel.** MÄRTENS. (Gefüge des Flusseisens.) "Organ." 1913, 14, pp. 256-58. Ill. 3s. 6d. No. 8428

**STRENGTH OF MATERIALS.**

**Influence of Boring on the Resistance of Mild Steels.** BIRAULT, C. (Influence du perçage sur la résistance des aciers doux.) "Gen. Civ." Vol. 63, 12, pp. 230-2. Ill. (The result of a series of tests, which is given in this article, shows that the holes drilled through the testing bars weaken the bars in a much less degree than is generally assumed.) 2s. 6d. No. 8429

**On the Stresses Arising in Machine Parts with Sharp and Round Edges.** BACH, C. (Zur Beanspruchung von Maschinenteilen mit scharfen oder ausgerundeten Ecken.) "Z. Ver. D. Ing." Vol. 57, 40, pp. 15.94-5. Ill. 2s. 6d. No. 8430

**TESTING MACHINES.**

**The 1,000 Ton Material Testing Machine, Type Emery, of the Bureau of Standards, Wash.** KURREIN, M. (Die 1,000-t-Material pruefmaschine, Bauart Emery, des Bureau of Standards in Washington.) "Z. Ver. D. Ing." Vol. 57, 29, pp. 1,225-32. Ill. 2s. 6d. No. 8431

**The 3,300 Ton Testing Machine at Berlin.** "Eng. News." Col. 70, 12, pp. 537. Ill. 2s. No. 8432

**TESTING OF MATERIALS.**

**Contribution to the Testing of Cast Iron.** JUENGST, C. (Beitrag zur Untersuchung des Gusseisens.) "Stahl Eisen." Vol. 33, 35, pp. 1,423-33. 3s. No. 8433

**Experiments with Thirty Boiler Plates with Cracks.** BAUMANN, R. (Dreissig Kesselbleche mit Rissbildung.) "Stahleisen." Vol. 33-38, pp. 1,554-61. Ill. 3s. No. 8434

## VI.—Lifting and Conveying Machines.

**GENERAL.**

**The Mechanical Handling of Clay and its Finished Products.** "Brick Pott. Tr. Jl." Vol. 21, 10, pp. 397-8. 1s. 6d. No. 8435

**Coal Unloading Machines at Fort William Ont.** WILLIAMS, R. D. "Iron Tr. Rev." Vol. 53, 14, pp. 578-80. (First application of the Hulett unloader to the problem of discharging coal cargoes from vessels.) 2s. 6d. No. 8436

**CONVEYORS.**

**Combined Pneumatic Conveyor Plant.** HERZOG, A. (Kombinierte pneumatische Transportanlage.) "Uhland. Spec. Ed." IV., p. 26. Ill. (The plant is used for conveying grain.) 2s. 6d. No. 8437

**Conveyors and Their Use.** EISENKRAMER, LUDWIG. (Conveyer und ihre Anwendung.) "Uhland. Spec. Ed." IV., 8, pp. 29-30. Ill. (The Gravity Conveyors are described.) 2s. 6d. No. 8438

**Modernisation of Conveying Plants.** "Coal Age." Vol. 4, 12, p. 413. Ill. (A description of a telpher system that transports coke from the oven bench direct to the mouth of the blast furnace without removal from its original bucket. Breakage is thus reduced to a minimum.) 1s. No. 8439

**Pneumatic Conveying Plants: A Simple Modern Conveying Device instead of Mechanical Devices.** KUHN, O. (Pneumatische Foerderanlagen, ein vereinfachtes modernes Foerdermittel an der Stelle mechanischer Foerdereinrichtungen.) "Werkstattstechn." Vol. 7, 16, pp. 496-8. Ill. 2s. 6d. No. 8440

**Pacific Mills Coal—and Ash Handling Equipment.** "Power." Vol. 38, 13, p. 425. Ill. (A coal and ash handling system consisting of three distinct parts. The first is a pivoted bucket conveyor to transfer the coal from the cars to the coal bunkers. The second part consists of charging cars for conveying coal from the bunkers to the boiler room, and the third part is an industrial railway system for removing ashes.) 1s. No. 8441

**Electric Induction Transport System for Mails.** "Engineering." Vol. 94, 2,493, p. 501. Ill. 1s. No. 8442

**Electric Carrier Railways for Rapid Transfer of Mail and Express.** "Eng. News." Vol. 70, 14, pp. 637-9. Ill. 2s. No. 8443

**New Electric Carrier for Mail or Package Freight.** "Eng. Rec." Vol. 68, 14, p. 397 Ill. 1s. No. 8444

**Electric Carrier System.** "Railway Age Gaz." Vol. 55, 14, pp. 624-5. 3 fig. (A

LIFTING AND CONVEYING MACHINES.

device now being perfected to transport mail or moderate sized packages in large buildings, such as terminals, warehouses, etc.) 1s. 6d. No. 8445

**American Excavators.** CHRIST, A. (Amerikanische Löffelbagger.) "Uhland. Spec. Ed." IV., 8, pp. 30-1. Ill. (Description of three automobile excavators.) 2s. 6d. No. 8446

**CRANES.**

**New Type of Motor Winch.** "Motor Boat." Vol. 19, 481, p. 246. Ill. (A solution of the ships auxiliary deck machinery problem. 6d. No. 8447

**ELEVATORS.**

**Grain Hauling and Storing Plant.** SPIELVOGEL, W. (Die Foerderanlagen der Speicherei und Speditions-A.G. Dresden-Riesa.) "Z. Ver. D. Ing." Vol. 57, 38, pp. 1,498-1,503. Ill. 2s. 6d. No. 8448

**HAULAGE.**

**Rope Haulage at Vesta No. 4 Mine.** PRICE, W. Z. "Colliery Eng." Vol. 34, 3, pp. 135-7. 7 fig. (Description of what is probably the greatest system of mechanical haulage in the coal mining world.) 2s. 6d. No. 8449

**Haulage Plant at the Friedensgrube Colliery, Upper Silesia.** PUETZ, O. (Foerdereinrichtungen der Friedensgrube in Friedenshuette O.S.). "Glueckauf." Vol. 49, 35, pp. 1,384-91, 10. Ill. 2s. 6d. No. 8450

**Coal Hauling Plants Combined with Bunkers and Mechanical Stoking.** EICHHOLTZ, A. (Kohlenfoerderanlagen in Verbindung mit Hochbunkern und mechanischer Rostbeschickung.) "Feuerungst." Vol. 1, 24, pp. 430-3. Ill. 2s. 6d. No. 8451

**Electrically Driven Main-Shaft Hauling Engine with Steam Turbine and Starting Dynamo.** BLAU, E. (Elektrisch betriebene Hauptschachtfoerdermaschinen mit Dampfturbinenantrieb der Anlassdynamo.) "El. Maschbau." Vol. 31, 37, pp. 779-82. Ill. 2s. 6d. No. 8452

**New Cascade Motors, Type Sandycroft-Hunt.** RICKER, A. (Neue Kaskaden-Motoren, Bauart Sandycroft-Hunt.) "Z. Ver. D. Ing." Vol. 57, 38, pp. 1,503-7. Ill. (Application for a hauling plant at an Indian coal mine.) 2s. 6d. No. 8453

**ROPEWAYS.**

**Automatic Aerial Wire Ropeways.** "Surveyor." Vol. 44, 1,135, pp. 604-5. Ill. 1s. No. 8454

# VII.—Pumps.

**GENERAL.**

**A Remarkable Pump.** (Eine merkwürdige Pumpe.) "Uhland." Spec. Ed. III., 8, pp. 30-1. Ill. (The so-called spiral wire pump is described by which liquids are raised by a spiral chain moving in the water and lifting it up.) 2s. 6d. No. 8455

**CENTRIFUGAL PUMPS.**

**The Theory of Centrifugal Pumps.** DAUGHERTY, R. L. "Mech. World." Vol. 54, 1,395, p. 147. Ill. 6d. No. 8456

**Theoretical and Graphical Study on Centrifugal Pumps.** DEJUST J. (Étude théorique et graphique des pompes centrifuges.) "Rev. Mec." Vol. 33, 3 pp. 209-56. Ill. 2s. 6d. No. 8457

**The Approximate Construction of the Q-Hn and the Efficiency Curves of Turbine Pumps.** OESTERREICHER, A.S. (Die angenaeherte Konstruktion der Q-Hn und der Wirkungsgradkurven fuer Kreiselpumpen.) "Z. Ver. D. Ing." Vol. 57, 29, pp. 1,148-9. Ill. 2s. 6d. No. 8458

**Design and Calculation of Centrifugal Pumps.** SCHMIDT, KARL. (Konstruktions- und Berechnungsbeispiele zu Zentrifugalpumpen.) "Uhland. Spec. Ed." III., 1913, 7, p. 28; 8, pp. 31-32. Ill. 5s. No. 8459

**A New Centrifugal Pump with Helicoidal Impeller.** KERR, C. V. "Jl. Am. Soc. Mech. Eng." Vol. 35, 10 pp. 1,493-1,524. 2s. 6d. No. 8460

**Pulsometer Multi-Stage Centrifugal Turbine Pumps.** "Page's Wly." Vol. 23, 472, p. 417. Ill. 1s. No. 8461

**PISTON PUMPS.**

**The Oddie-Simplex Steam Pump.** (Die Oddie-Simplex Dampfpumpe.) "Uhland. Spec. Ed." III., 7, pp. 26-8. Ill. 2s. 6d. No. 8462

**A Reversing Pump.** (Die vor-und rückwärtslaufende Pumpe eine Tatsache.) "Uhland. Spec. Ed." III., 8 pp. 29-30. Ill. (Description of a pump which allows of suction or pressure at will.) 2s. 6d. No. 8463

**On Axial Pumps.** WAGENBACH (Ueber Axialpumpen.) "Z. ges. Turbinenw." Vol. 10, 16, pp. 241-4. Ill.; 17, pp. 262-5. 4s. No. 8464

**Experiments with Large Annular Valves guided by Leaf Springs for Drainage Pumps and Contribution to the Dynamics of Valve Motion.** SCHOENE, K. (Versuche mit grossen, durch Blattfedern gefuehrten Ringventilen fuer Kanalisationspumpen und Beitraege zur Dynamik der Ventilbewegung "Z. Ver. D. Ing." Vol. 57, 32, pp. 1,246-55. Ill. 2s. 6d. No. 8465

**PUMPING PLANT.**

**Municipal Pumping Plants.** TAYLOR, F. N. "Pract. Eng." Vol. 48, 1,388, p. 317; 1,390, pp. 367-8. Ill. (Valves for reciprocating pumps.) 1s. No. 8466

**MISCELLANEOUS.**

**On the Arrangement of Circular Piston-Blowers.** (Etwas über Anordnung, etc., der Kreiskolbengebläse.) "Uhland. Spec. Ed." III., 7, pp. 25-6. Ill. (Data on suitable design of the machines and their use.) 2s. 6d. No. 8467

**Calculation of Compressed Air Pumps.** DARAPSKY, L. (Die Berechnung der Pressluftpumpen.) Dingler. Vol. 328, 32, pp. 497-500; 33, pp. 518-22; 35, pp. 548-51; 36, pp. 566-8; 37, pp. 582-85; 40, pp. 631-34. Ill. 15s. No. 8468

**A Rotary Hydro-Pneumatic Compressor.** "Iron Age." Vol. 92, 14, p. 712. Ill. (Single stage machine and vacuum pump for moderate pressures.) 2s. No. 8469

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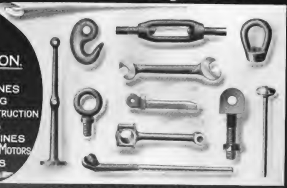

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# VIII.—Railway Engineering.

GENERAL.

**British Railway Progress. 1854 to 1912.** "Railw. News." Vol. 100, 2,597, p. 567. 1s. No. 8470

**Instruction of Trainmen on the Houston Electric Company.** "El. Railw. Jl." Vol. 42, 13, pp. 488-90. Ill. (The article describes the schoolroom equipment and complete course of instruction to prospective trainmen as conducted at Houston and also the method of teaching the instructors.) 1s. 6d. No. 8471

ACCIDENTS.

**A New Haven Collision of September 2nd, 1913, Abstract of Report of the Inter-state Commerce Commission.** "Railw. Eng. Rev." Vol. 53, 39, pp. 913-17. 1s. No. 8472

**Report on Hays Mill Wreck: Transverse Fissures in Steel Rails.** "Railw. Eng. Rev." Vol. 53, 39, pp. 309-11. Ill. 1s. No. 8473

**The Colchester and other Railway Accident Reports.** "Engineer." Vol. 106, 3,013 p. 333. 1s. No. 8474

**Report on North Haven Collision.** "Railway Age Gaz." Vol. 55, 14, pp. 619-22. 1s. 6d. No. 8475

**Collision on the Pennsylvania Railroad at Tyrone, Pa.** "Railw. Eng. Rev." Vol. 53, 38, p. 886. Ill. 1s. No. 8476

AERIAL RAILWAYS.

**Aerial Mountain Railways.** BUHLE, M. (Berg-Seilschwebebahnen.) "Organ." 1913. 15, pp. 266-72. Ill. (Aerial Ry., Lana-Vigiljoch, Chamonix-Aiguille du Midi, Brixen-Plose are described.) 2s. 6d. No. 8477

**Passenger Aerial Railway of Pain de Sucre in Rio de Janeiro.** DANTIN, CH. (Funiculaire aérien a voyageur du Pain de Sucre a Rio de Janeiro.) "Gen. Civ." Vol. 63, 13, pp. 253-6. Ill. (The ropeway climbs with only two tracks of 517 and 800 m. the famous mountain of Paóde Assucar.) 2s. 6d. No. 8478

**Rope Suspension Railway to Kohlern near Bozen.** WETTICH, H. (Seil-Schwebebahn nach Kohlern bei Bozen.) "Organ." Vol. 50, 19, pp. 341-2. Ill. 2s. 6d. No. 8479

**Recent Electrical Suspended Railways.** (Neues über Elektrohängebahnen.) "Uhland. Spez. Edit." IV., p. 28. 8 ill. (Description of motor and block system.) 2s. 6d. No. 8480

**Rope Suspension Railways for Carrying Passengers.** WINTERMEYER. (Seilschwebebahnen (mit Antrieb) zur Personenbeförderrung.) "El. Kraftbetrieb u.B." Vol. 11, 24, pp. 484-9. Ill. (Various plants are described.) 1s. 6d. No. 8481

BRAKES AND COUPLINGS.

**New Practical Experience with the Continuous Goods-train Brake, System Hardy.** GLANZ. (Neue Erfahrungen im Betriebe mit der durchgehenden Güterzugsbremse "System Hardy.") "Glaser." Vol. 73, 4, pp. 75-7. (Particularly the costs of maintenance are dealt with.) 2s. 6d. No. 8482

**Braking Goods Trains by the Continuous Vacuum Brake, "Hardy."** NEBLINGER, JACQUES. (Le freinage des trains de marchandises par le frein à vide, "Hardy.") "Gen. Civ." Vol. 63, 14, pp. 268-71. (Description of different parts of the brake; its operation.) 2s. 6d. No. 8483

**The Law of the Brake-Power Phenomenon on Railway Trains.** MEYER-ABSBERG, J. (Gesetzmässigkeiten im Verhalten der Bremskraft bei Eisenbahnzügen.) "Organ." Vol. 50, 18, pp. 330-2. Ill. 2s. 6d. No. 8484

CONSTRUCTION.

**The Railways of Our Indian Empire: Their Construction and Progress.** "Railw. News." Vol. 100, 2597, pp. 570-1. (Transport and earnings. Goods.) 1s. No. 8485

**Features of the Kalka-Simla Railway.** FREEMAN, L. R. "Railway Age Gaz." Vol. 55, 15, pp. 657-8. 3 fig. (Heavy protective work necessary on this narrow gauge line up the Himalaya results in high construction cost.) 1s. 6d. No. 8486

**The Construction of the East African Central Railway.** GILLMANN, C. (Vom Bau der Ostafrikanischen Mittellandbahn.) "Schweizerische Bauz." Vol. 62, 12, pp. 160-66. Ill.; 13, pp. 176-9. Ill. 3s. No. 8487

**Construction of the Buckhannon and Northern Railroad.** KERR, R. E. "Railway Age Gaz." Vol. 55, 14, pp. 617-8. 4 fig. 1s. 6d. No. 8488

**Continuation of Louisville and Nashville Improvements in Eastern Kentucky.** "Eng. Rec." Vol. 68, 13, pp. 359-60. Ill. (Features of reconstruction and new construction from Irvine East.) 1s. No. 8489

**Factors Entering into Grade Reductions.** "Eng. Rec." Vol. 68, 14, pp. 375-6. (Analysis of the estimated saving in a proposed change from a 0.6 to a 0.3 per cent. ruling grade on a typical 130-mile division.) 1s. No. 8490

**Reduced Live Loads on Railway Underbridges.** BALL, J. D. W. "Engineer." Vol. 106, 3015, pp. 377-8. Ill. 1s. No. 8491

**Adopted Design of the Quebec Bridge.** MODJESKI, R. "Railway Age Gaz." Vol. 13, pp. 559-62. (Discussion of elements considered in designing the longest span in the world.) 1s. 6d. No. 8492

**The Halen Reinforced Concrete Bridge.** BERN, Switzerland. "Eng. News." Vol. 70, 12, pp. 531-5. Ill. 2s. No. 8493

**Double Deck Bascule Bridge.** "Railway Age Gaz." Vol. 55, 14, pp. 603-4. 4 fig. (The problem of building a double deck bascule bridge solved without adding a single extra detail or joint.) 1s. 6d. No. 8494

**Bridges of the Connecticut Company.** "El. Railw. Jl." Vol. 42, 14, pp. 638-40. Ill. (Views and brief descriptions of a number of bridge structures are presented together with an account of an extended bridge investigation which includes approximate methods of determining loading.) 1s. 6d. No. 8495

ECONOMICS, ADMINISTRATION AND STATISTICS.

**The Elements of Railway Operating Econo-**

**RAILWAY ENGINEERING.**

**mics.** "Railw. News." Vol. 100, 2596, p. 539; 2597, p. 572. (Locomotive operation.) 2s. No. 8496

**British Railway Receipts and Expenses, 1854-1912.** "Railw. News." Vol. 100, 2597, p. 566. 1s. No. 8497

**Results Obtained in 1911 on the French State Railways According to the Report Published by the Administration Board.** (Résultats obtenus en 1911 sur le réseau des Chem. de Fer de l'État en France, d après le compte d' Administration publié pour la dite année.)" "Rev. Gen. Chem. Fer." 1913, 1, pp. 51-60. (The results are compiled in 11 tables.) 3s. No. 8498

**Results Obtained in 1912 on the Five Principal French Railways.** (Résultats obtenus 1912 sur les réseaux des cinq Compagnies principales des Chemins de Fer francais.) "Rev. Gen. Chem. Fer." 1913, 2, pp. 101 34. (Statistical data compiled in tables.) 3s. No. 8499

**Statistics of Algerian and Tunisian Railways, 1910.** (Statistique des Chemins de Fer Algériens et Tunisiens, 1910.) "Rev. Gen. Chem. Fer." 1913, 3, pp. 159-63. 3s. No. 8500

**ELECTRIC RAILWAYS AND TRAMWAYS.**

**Railway Electrification.** SPARKS, J. B. "El. Times." Vol. 44, 1147, pp. 346-8; 1148, pp. 374-5. (A comparative analysis of the single-phase and H.T. direct current costs estimated for the Melbourne suburban system.) 1s. No. 8501

**Limits of Capacity of Urban High Speed Railways.** BRUGSCH and BRISKE. (Die Grenzen der Leistungsfähigkeit von Stadt-Schnellbahnen.) "El. Kraftbetrieb u. B." Vol. 11, 27, pp. 553-7 Ill. (With trains of 60 m. length the greatest number of passengers conveyed per hour amounts to 29,000 in each direction; with 150 m. 55,000.) 1s. 6d. No. 8502

**Hypothetical Electric Interurban Railways.** "El. Railw. Jl." Vol. 42, 12, pp. 460-2. (A theoretical application of the principles governing the operating revenue, operating expense and cost of construction of proposed electric interurban railways.) 1s. 6d. No. 8503

**Economic Value of Electrical Main Railway Service.** USBECK, W. (Die wirtschaftliche Bedeutung des elektrischem Hauptbahnbetriebes.) "Etz." Vol. 34, 34, pp. 963-7. (Short historical survey; the different kinds of electric service on main lines and their advantages over steam service are discussed.) 3s. 6d. No. 8504

**The Electric Railways in the Rhenisch Westphalian Industrial District.** BASWITZ, HANS. (Die elektrischen Bahnen im Rheinisch-Westfälischen Industriegebiete.) "El. Kraftbetrieb. u. B." Vol. 11, 25, pp. 501-4. 1s. 6d. No. 8505

**Electrification of Steam Railroads in Mountain Districts.** "Eng. Rec." Vol. 568, 12, p. 314. 1s. No. 8506

**Electric Railway Construction in Paris.** "El Railw. Jl" Vol. 42, 14, pp. 648-50 Ill. (The principal surface electric rehabilitation. The standard car will have a centre entrance and will be mounted on a single truck with an 11-ft 10 in wheelbase) 1s. 6d. No. 8507

**Hydro-electric Energy for Worcester Railway System.** "El. World." Vol. 62, 14, pp. 685-8. Ill. (Features of Connecticut River Transmission Company's 120,000-volt lines and sub-stations. Outdoor switching installation. Additions to Millbury plant.) 1s. No. 8508

**Study on Electrification of Southern Pacific Mountain Division.** "Railw. Eng. Rev." Vol. 53,40, p. 939. (Discussing a hypothetical installation of electric motive power on the Southern Pacific Line over Tehachapi Pass, the author derives an estimate of the first cost involved and the comparative operating expenses. He finds no possibility of financial profit in electric operation.) 1s. No. 8509

**Newark-Trenton High-Speed Line.** "El. Railw. Jl." Vol. 42, 12, pp. 455-9. Ill. 1s. 6d. No. 8510

**Tramway of Warsaw (Strassenbahn Warschaus).** "El. Kraftbetrieb u. B." Vol. 11, 25, pp. 514-16. Ill. (The power station is especially dealt with.) 1s. 6d. No. 8511

**Opening of the Section Spittelmarkt-Alexanderplatz of the Berlin Underground Railway.** KEMMANN, G. (Zur Eröffnung der Strecke Spittelmarkt-Alexanderplatzder Berliner Untergrundbahn.) "El Kraftbetrieb u. B." Vol. 11, 22, pp. 441-51. Ill. (The Automatic signalling system is specially dealt with.) 1s. 6d. No. 8512

**Service Experience with Electric Train Traction at Simplon.** KILCHENMANN, BRUNO. (Betriebserfahrungen bei der elektrischen Zufförderung am Simplon.) "El. Kraftbetrieb u. B." Vol. 11, 21, pp. 429-39. Ill. (Power Stations, contact line, Locomotives. 1s. 6d. No. 8513

**Up-to-date Auxiliary Devices for Large Electric Railways.** (Zeitgemässe Hilfseinrichtungen im grossen elektrischen Bahnbetriebe.) "El Kraftbeitrieb u. B." Vol. 11, 25, pp. 522-8. Ill. (Pneumatic stamping devices, compressed air hammers, rail planers, apparatus for autogenous welding, rail millers, and electric rail drillers are described.) 1s. 6d. No. 8514

**Diesel-Electric Rail Motor Cars on Swedish State Railways (Dieselelektrische Triebwagen der schwedischen Staatsbahnen.)** "Organ." Vol. 50, 17, pp. 311-13. Ill. (Diesel engine of 75 HP. drives continuous current generator of 50 kilwatt.) 3s. 6d. No. 8515

**Control of Electric Goods Train Locomotive. E. G. 506 of the Prussian Railway Administration.** RICHTER, RUDOLF. (Die Steuerung der elektrischen Güterzuglokomotive EG506 der preussischen Eisenbahnver waltung.) "ETZ." Vol. 34, 31, pp. 867-71. Ill. 3s. 6d. No. 8516

**Notes on the Locomotives for the Mittenwald Railway.** SEEFEHLNER AND POPP. "Electrician." Vol. 71. 1845, pp. 1025-7. 1s. No. 8517

**Single-Phase Locomotives for the Rhaetian Railway.** "Engineer." Vol. 106, 3,014, p. 359. Ill. 1s. No. 8518

RAILWAY ENGINEERING.

**Adoption of Accumulator Rail-Motor-Car Service on the Lines Mulheim Ruhr-Heissen-Osterfeld-Nord and Mulheim-Ruhr-Heissen-Hattingen and Contribution to the Question of the Economy of Motor Car Service.** BORGHAUS, E. (Die Einführung des Akkumulator-Triebwagenbetriebes auf den Strecken Mülheim-Ruhr-Heissen-Osterfeld-Nord und Mülheim-Ruhr-Heissen-Hattingen und Beitrag zur Frage der Wirtschaftlichkeit des Triebwagenbetriebes.) "Glaser." Vol. 73, 4, pp. 63-71. Ill. (Description of plant, calculation of rentability comparing steam service and motor car service with each other). 2s. 6d. No. 8519

**Rail Motor-Car Equipment of the Chemin de Fer departementaux de la Haute-Vienne.** WICHERT, A. (Die Triebwagenausrüstungen derf Chemin de Fer départementauxde la Haute-Vienne.) "El. Kraftbetrieb u. B." Vol. 11, 23, pp. 461-72. Ill. (Power generation and distribution; the motor cars and their equipment, description of the most important parts of equipment, results of tests.) 1s. 6d. No. 8520

**Designs of One-storied Tram Cars and Autobuses for the Municipal Tramways of Vienna.** SPRÄNGLER, LUDWIG (Entwurfe für stockhohe Tramwagen und Automobiomnibusse bei den Wiener städtischen Strassenbahnen.) "El Kraftbetrieb u. B." Vol. 11, 25, pp. 504-14. Ill. 1s. 6d. No. 8521

**Maintenance Costs of Old and New Railway Motors.** "El. Railw. Jl." Vol. 42, 13, pp. 495-7. (A comparison of the costs of operating old and modern types of motors in city and interurban service, based upon figures taken from six roads in operation.) 1s. 6d. No. 8522

**The Electric Truck: English Experiments and American Practice.** "El. Rev." Vol. 73, 1871, pp. 539-40. Ill. 1s. 8523

LIGHTING.

**Installation and Maintenance of Electric Headlight Equipment.** "Railway Age Gaz." Mech, Ed." Vol. 87, pp. 546-9. 14 fig. 1s. 6d. No. 8524

**Car Lighting Tests on the Bay State Street Railway.** "El. Railw. Jl." Vol. 42, 13, pp. 504-5. 1s. 6d. No. 8525

LOCOMOTIVES.

**Steam Locomotives Problems.** "Times Eng. Supp." 450, p. 21. (High speeds and heavy loads.) 1s. No. 8526

**The First Diesel (Thermo) Locomotive.** STERNENBERG, F. (Die erste Thermo-Lokomotive.) "Z. Ver. D. Ing." Vol. 57, 34, pp. 1,325-31. Ill. (Full description and working results of this locomotive which is driven by a 1,000 H.P. Diesel engine.) 2s. 6d. No. 8527

**The First Diesel Locomotive.** ALLEN, P. R. "Cass. Eng. Mly." Vol. 44, 4, pp. 259-264. Ill. 1s. No. 8528

**The Locomotives at the Ghent World's Fair.** PIERRE-GUÉDON L. (Les locomotives à l'Exposition de Gand.) "Gen. Civ." Vol. 63, 12, pp. 225-7. Ill. (Locomotive type, "Lorraine," with single expansion and superheating and five coupled wheels is described. Grate area 3,08 sqm. Results of working. Superheater Mestre.) 2s. 6d. No. 8529

**New 4-4-0 Locomotive: Great Central Railway.** "Railw. News." Vol. 100, 2,596, p. 544. Ill. (Designed by Mr. G. J. Robinson, Chief Mechanical Engineer.) 1s. No. 8530

**Great Southern and Western Railway Express Passenger Locomotive.** "Railw. Gaz." Vol. 19, 13, pp. 341-3. Ill. 1s. No. 8531

**The Forty-thousandth Locomotive Constructed by the Baldwin Locomotive Works.** "Railw. News." Vol. 100, 2,596, p. 543. Ill. 1s. No. 8532

**Recent Passenger and Goods Train Locomotives of the New York, New Haven and Hartford Ry. and Boston and Maine Ry.** HELLMUND, R. E. (Neuere Personenzugs-und Güterzugslokomotiven der New York, New Haven and Hartford Bahn und Boston and Maine Bahn). "El. Kraftbetrieb u. B." Vol. 11, 26, pp. 533-42. (Submission terms and conditions of service of the locomotive; general data concerning locomotion; motor drive, construction of locomotive frame, motors, switches, equipment, results of service are dealt with.) 1s. 6d. No. 8533

**Powerful Locomotives of the Bone Guelma Railway and Its Extensions.** FÉLIX, M. L. (Locomotives Puissantes de la Compagnie Bone-Guelma et prolongements.) "Rev. Gen. Chem. Fer." 1913, 2, pp. 95-7. Ill. (Single expansion with superheater Schmidt, 5 axles coupled.) 2s. 6d. No. 8534

**The African Railways.** (Les Chemines de Fer Africains). "Rev. Gen. Chem. Fer." 1913, 1, S. 14-50. Ill. (Typical modern locomotives and rollingstock are described.) 2s. 6d. No. 8535

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**4-6-0 Express Locomotives, Bombay, Baroda & Central India Ry.** Metre Gauge Section. "Locomotive." Vol. 19, 254, pp. 230. Ill. 6d. No. 8537

**Pacific Type Locomotives for the Baltimore and Ohio R.R.** "Railw. Eng. Rev." Vol. 53, 38, p. 884. Ill. 1s. No. 8538

**Pacific Type Locomotive for the Pennsylvania Lines West of Pittsburgh.** "Railw. Eng. Rev." Vol. 53, 40, pp. 934-6. Ill. (This locomotive is a heavy Pacific type fast passenger locomotive, typical of the design adopted by the Pennsylvania system for this class of service some three or four years ago. It is fitted with superheater and brick-arch equipment and is fired by means of a Crawford underfeed mechanical stoker.) 1s. No. 8539

**New Locomotives for the Santa Fe.** "Railway Age Gaz. Mech. Ed." Vol. 87, 10, pp. 525-7. 3 fig. 1s. 6d. No. 8540

**Gasoline Freight and Switching Locomotive for the Minneapolis and Northern Railw.** "Railway Eng. Rev." Vol. 53, 38, p. 888. 1s. No. 8541

**The Storage Battery Locomotive.** ANDERSON, A. R. "Colliery Eng." Vol. 34, 3,

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pp. 146-50. 5 fig. (Its application to gathering coal in mines; methods of calculating size of locomotives and battery needed.) 2s. 6d. No. 8542

**Gasoline Motors in Coal Mines.** KING, A. J. "Colliery Eng." Vol. 34, 3, pp. 164-5. 2 fig. (Extent to which they vitiate the air. Additional quantity of air to be supplied.) 2s. 6d. No. 8543

**Gasoline Mine Locomotives.** SCHOLZ, C. "Colliery Eng." Vol. 34, 3, pp. 153-4. 2s. 6d. No. 8544

**Condensed Record of Locomotive Equipment.** SWARTZ, R. M. "Railway Age Gaz. Mech. Ed." Vol. 87, 10, pp. 527-9. 5 fig. 1s. 6d. No. 8545

**Location of Steam Gauges in Setting Safety Valves.** "Railway Age Gaz. Mech. Ed." ROMMEL, C. T. Vol. 87, 10, pp. 533-6. 3 fig. 1s. 6d. No. 8546

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**Alterations Made on the Old Locomotives of the Portuguese Railways.** D'ANGLARDS, HENRY LAVIALLE. (Transformations faites sur les anciennes locomotives de la Compagnie des Chemins de fer Portuguais.) "Rev. Gen. Chem. Fer." 1913, 3, pp. 149-58. Ill. 2s. 6d. No. 8553

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**Running Past the "Stop" Signal on Inclines.** MARTENS, HANS A. (Das Ueberfahren des "Halt" Singals auf Gefällstrecken.) "Organ." Vol. 50, 18, pp. 329-30. (Proposal to put warning signals for calling the attention of the brakemen to the change of gradients.) 2s. 6d. No. 8571

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**Cab Signals and Train Stops.** DAMMOND, W. H. "Cass. Eng. Mly." Vol. 44, 4, pp. 240-8. Ill. 1s. No. 8576

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**Ita's Business Motors.** "Motor Traction." Vol. 17, 449, pp. 405-6. Ill. 6d. No. 8637

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**The 25-30 H.P. Six-cylinder Studebaker.** "Autocar." Vol. 31, 936, pp. 569-70. Ill. (Bore and stroke 90 by 127 m.m. Monobloc engine. Electric lighting and engine starting.) 6d. No. 8639

**The 1914 Panchard Cars.** "Autocar." Vol. 31, 936, p. 581. (Four models of similar design, two with knight engines and two with poppet valves.) 6d. No. 8640

**The 12-15 H.P. Sizaire Naudin.** "Autocar." Vol. 31, 936, p. 583. Ill. (Four cylinders 75 by 120 m.m. Four speeds.) 6d. No. 8641

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**Swift Cars for 1914.** "Autocar." Vol. 31, 937, p. 619. Ill. (Two new models and an improved light car with two cylinders.) 6d. No. 8643

**The 15·9 H.P. Cheswold Car.** "Autocar." Vol. 31, 937, p. 625. Ill. (A Yorkshire-built car on accepted general lines with special points in detail designs.) 6d. No. 8644

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**The Tweenie Light Car.** "Autocar." Vol. 31, 937, p. 638A. (Four-cylinder engine, 65 by 110 m.m. and stroke. Friction transmission with final drive by single chain. Friction differential.) 6d. No. 8646

**Four Daimler Models for 1914.** "Autocar." Vol. 31, 937, p. 612. 6d. No. 8647

**The New De Dion Models.** "Autocar." Vol. 31, 937, p. 604. 6d. No. 8648

**The 1914 B.S.A. Car.** "Autocar." Vol. 31, 938, p. 635. Ill. (Particulars of the new standard type of body and other details.) 6d. No. 8649

**The New Darracq Cars.** "Autocar." Vol. 31, 938, p. 682. Ill. (Three models with poppet valve engines. Commendable variations in chassis details.) 6d. No. 8650

**1914 Gregoire Cars.** "Autocar." Vol. 31, 938, p. 685. Ill. (A new model with a T-head engine and two-spark magneto.) 6d. No. 8651

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**Does it pay to Buy Second Hand Motor Cars?** König, Ad. (Lohnt es sich, gebrauchte Automobile zu kaufen?) "Motorwagen." Vol. 16, 26, pp. 652-54. (Examples showing when it is advantageous to purchase a second hand motor car.) 2s. No. 8655

## X.—Shipbuilding and Marine Engineering.

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**Development and Status of German Sailing Sport.** von Viebahn, F. W. (Entwicklung und Stand des deutscher Segelsports). "Schiffbau." Vol. 14, 22, pp. 933-40. Ill. 3s. No. 8659

**The Netherland Navigation Exhibition at Amsterdam.** Kielhorn, C. (Die niederländische Schiffahrts-Ausstelung zu Amsterdam.) "Schiffbau." Vol. 14, 24, pp. 1,040-44. 3s. No. 8660

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**Bending Stress on Mast Fittings.** Stieghorst, J. (Biegungsbeanspruchung von Mastbeschlägen.) "Schiffbau." Vol. 14, 21, pp. 899-904. Ill. (Determination of bending stress of simple rivetted-on rings.) 3s. No. 8661

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**Recent Experiences of Babcock and Wilcox Boilers for Marine Purposes.** ROSENTHAL, J. H. "Inst. Mar. Eng." Vol. 25, 201, pp. 191-242. 2s. 6d. No. 8665

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**The Designing of Marine Diesel Engine Reversing Gears, from the Practical Point of View.** ROTHARHT. O. (Praktische Gesichtspunkte fuer den Entwurf von Umsteuerungen beim Schiffsdieselmotor.) "Oelmotor," Vol. 2, 4, pp. 326-8. 3s. 6d. No. 8669

**A New Launch Engine.** "Int. Comb. Eng." Vol. 3, 56, pp. 654-8. Ill. 1s. No. 8670

**Diesel Engines for Driving Ships' Dynamos.** LAUDAHN, W. (Dieselmaschinen zum Antrieb von Borddynamos in der deutschen Kriegs-marine.) "Oelmotor." Vol. 2, 3, pp. 189-205. Ill. 4, pp. 289-109. Ill. (Particulars of the requirements laid down by the German Admiralty for electricity generating sets of this description.) 7s. No. 8671

**Relation Between the Dimensions of Starting Valves and the Starting Phenomena on Marine Oil Engines.** (Bezehungen zwischen dem Abmessungen der Anfahrventile und dem Anfahrvorgang bei Schiffsoelmaschinen.) ABELEIN, K. "Z. Ver D. Ing." Vol. 57, 31, pp. 1,223-7. Fig. 2s. 6d. No. 8672

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**The Motor Ship, "Manuel Nobel."** "Int. Comb. Eng." Vol. 3, 56, pp. 658-9. 1s. No. 8689

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**Working Results of the MS.** "Rolandseck." WESSELS, G. (Betriebsergebnisse vom Motorschiff "Rolandseck.") "Oelmotor." Vol. 2, 4, pp. 328-31. 3s. 6d. No. 8691

**Two Notable Diesel-Engined Vessels.** "Shipping Rec." Vol. 2, 16, pp. 482-3. (The twin-screw motor ship, "Pedro Christophersen," and the motor ship, "California," built by Burmeister Wain, Copenhagen.) 1s. 6d. No. 8692

**The Performance of the Motorship, "Jutlandia,"** "Motor Boat." Vol. 19, 48 4, pp

253-4. Ill. Probable modifications in the new ships.) 6d. No. 8693

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**Influence of the Propeller Action on the Canal Bed.** FLAMM, O. (Die Wirkungen der Schiffsschraube auf die Kanalsohle.) "Schiffbau." Vol. 14, 23, pp. 981-89. Ill. (Report on trials made with a properly shaped plate applied to the rudder which protected the canal bed.) 3s. No. 8701

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**Large Motor Depot Ship for Submersibles.** "Motor Boat." Vol. 19, 484, pp. 302-3. Ill. 6d. No. 8704

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**Control of Public Wireless Telegraphy Traffic in Germany.** THURN, H. (Die Regelung des offentlichen Funkentelegraphenvekehrs in Deutschland.) "Schiffbau." Vol. 14, 22, pp. 947-51. (Conditions under which German steamers obtain a license from General Post Office to instal wireless plants on board. 3s. No. 8711

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**Recent Devices for Long Distance Power transmission without Continuous Wire.** WOLFF, W. (Neuere Einrichtungen zur Kraftübertragung in die Ferne ohne fortlaufenden Leitungsdraht.) "Schiffbau." Vol. 14, 23, pp. 999-1,002. Ill.; 24, pp. 1,044-8. (Systems of different inventors are described.) 6s. No. 8715

# XI.—Iron and Steel.

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## ANALYSIS AND SAMPLING.

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IRON AND STEEL.

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**The Application of Coal Tar Oil for Casting Purposes.** HAUSENFELDER. (Die Verwendung des Steinkohlenteeroeles im Giessereibetriebe.) "Giesserei Z." Vol. 10, 19, pp. 592-5. Ill. 2s. 6d. No. 8721

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**Modern Cleaning of Castings.** (Die moderne Gussputzerei.) KOOB, A. "Giesserei Z." Vol. 10, 18, pp. 570-4. 2s. 6d. No. 8725

**Bandaged Cast-iron, System Dr. von Emperger.** NITZSCHE, H. (Umschnuertes Gusseisen, System Dr. v. Emperger.) "Giesserei Z." Vol. 10, 17, pp. 525-35. Ill. (Cast iron in bars or columns is surrounded by a thin layer of concrete and tied round with steel wire; this system is elastic, of high resistance against pressure.) 2s. 6d. No. 8726

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**FOUNDRIES.**

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**The Utilization of Heat in the Electric Steel Furnace.** LOEBE, R. "Dingler." Vol. 328, 39, pp. 509-12. Ill. 40, pp. 628-31. Ill. (The most important modern induction furnaces are described.) 2s. 6d. No. 8743

**Progress in the Construction and Working of Electric Furnaces, Todenhauser, W.** (Fortschritte im Bau und Betrieb elektrischer Hochöfen.) "El. Kraftbetrieb u. B." Vol. 11, 27, pp. 561-66. Ill. (Design and working of electric furnaces for metals is fully dealt with. The furnace is largely adopted in Sweden; built in units up to 3,000 h.p.) 1s.6d. No. 8744

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die haeufig beim Einsatzhaerten gemacht werden.) "Z. Werkzeugmasch." Vol. 17 35, pp. 534-6. Ill. 2s. 6d. No. 8748

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**Usefulness of Permanent Moulds for Iron and Metal Casting.** MEHRTENS, J. (Die Brauchbarkeit bleibender Gussformen in der Eisen-und Metallgiesserei.) "Giesserei Z." Vol. 10, 18, pp. 557-61. Ill. 19, pp. 596-602. Ill. 5s. No. 8754

**Electric Moulding Machines.** LOHSE, U. (Elektrische Formmaschinen.) "Giesserei Z." Vol. 10, 12, pp. 369-7. Ill. 13, pp. 402-11. Ill. 15, pp. 473-8. Ill. 16, pp. 50-57. Ill. 10s. No. 8755

**Two New Osborn Moulding Machines.** "Iron Age." Vol. 92, 14, pp. 704-5. Ill. 2s. No. 8756

**Moulding Sand, Its Testing and Valuation.** IRRESBERGER, C. (Der Formsand, Seine Pruefung und Bewertung.) "Stahleisen." Vol. 33, 35, pp. 1433-38; 39, pp. 1595-1601. Ill. 6s. No. 8757

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**Influence of Vibrations and Heating on the Magnetic Properties of Sheet-Iron.** GUMLICH and STEINHAUS. (Einfluss von Erschuetterungen und Erwaermungen auf die magnetischen Eigenschaften von Eisenblech.) "Stahl Eisen." Vol. 33, 36, pp. 1477-71. 3s. No. 8763

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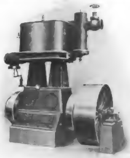

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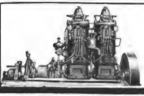



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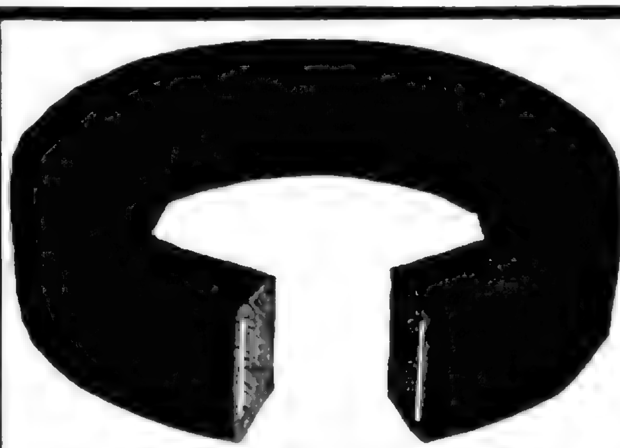

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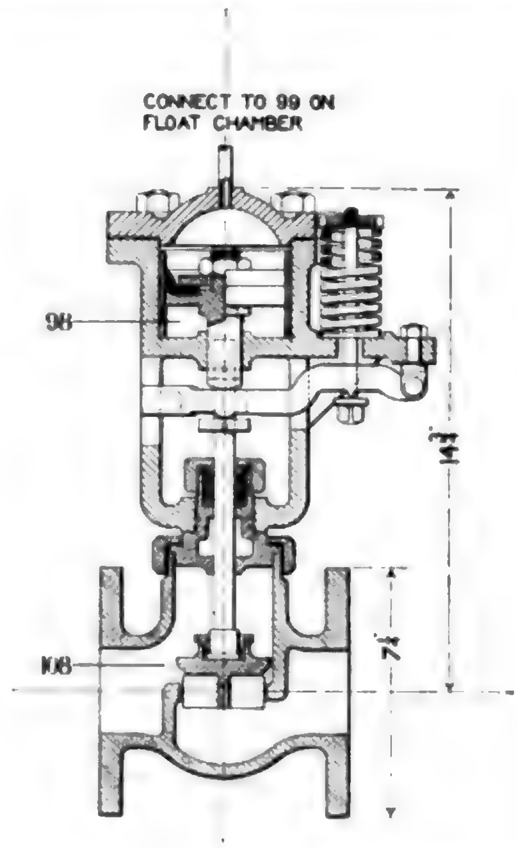


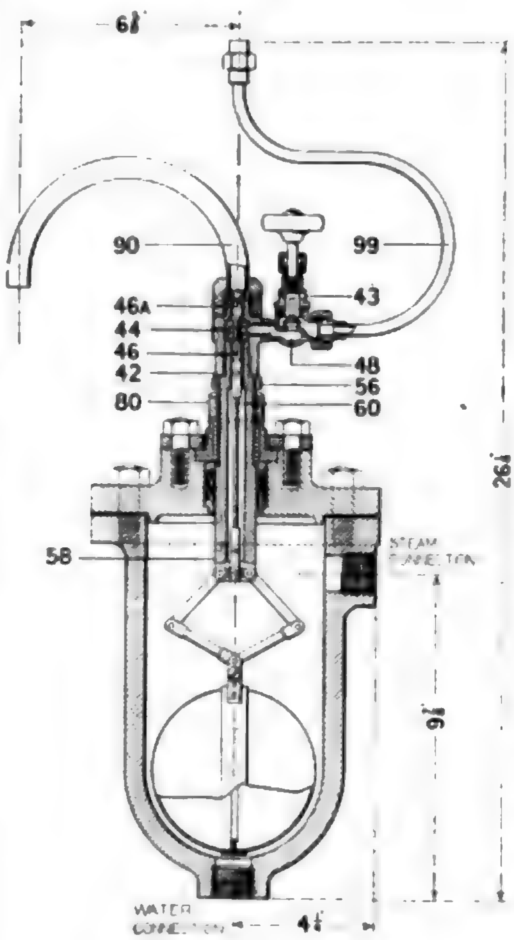


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**In cases where names are given in the classified index and the advertisements of such firms are not in this issue, they will be found in the following issue.**

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